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General Inventory for Spotted Bats (*Euderma maculatum*) on the Wasatch Plateau, Manti-La Sal National Forest, and the Old Woman Plateau and Thousand Lakes Mountain, Fishlake National Forest

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1992 Cooperative Challenge Cost Share Projects

UTAH DEPARTMENT OF NATURAL RESOURCES
Utah Natural Heritage Program

DEPARTMENT OF AGRICULTURE
Forest Service Intermountain Region

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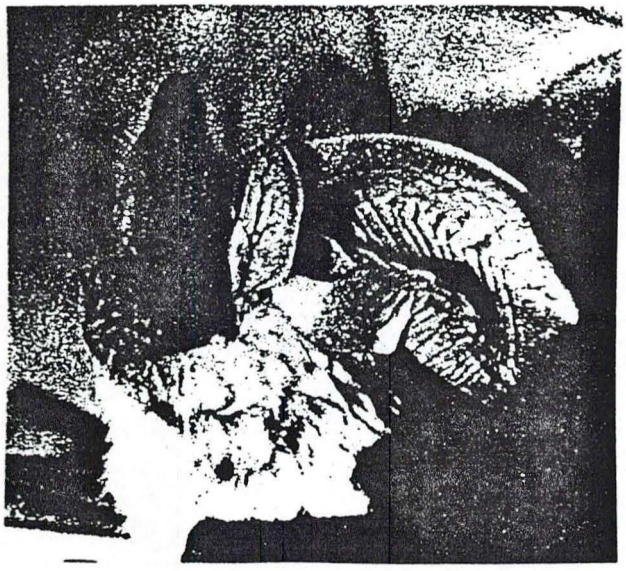

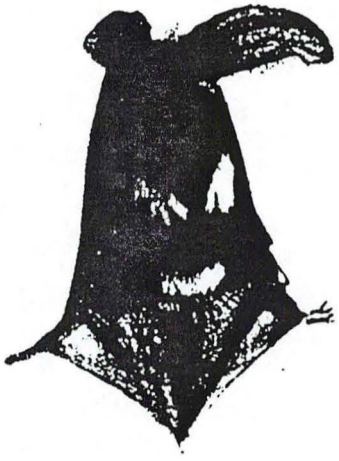

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INTRODUCTION

Euderma maculatum (spotted bat) is widely distributed throughout western North America from Mexico to southwestern British Columbia (O'Farrell 1981). However, researchers believe this species is rare throughout most of its range, with some exceptions in southcentral British Columbia and Texas where the spotted bat appears to be locally common (Fenton et al. 1987). The apparent rarity of spotted bats may be a function of their non-colonial behavior (Pederson pers. comm.), or their capacity to fly high and effectively avoid mist-nets. However, Fenton et al. (1987) report that in their echolocation survey of western bats, spotted bats are relatively uncommon.

There are few existing spotted bat population data available, so declines have not been well documented. O'Farrell (1981) suggests that in locations where spotted bats have been studied through time, the numbers of bats caught seem to have decreased. Further, O'Farrell (1981) indicates that the decline may be from over-collection for scientific purposes, or net-wary individuals that have been previously caught. Although, Poche (1981) has successfully recaptured individuals. Spotted bat population data need to be collected and analyzed over time to confirm the status of *Euderma* populations range-wide.

Until recently, a few museum and published records (Hasenyager 1980) were the only sources of known spotted bat locations in Utah. The distribution is scattered from Salt Lake City south to the Utah/Arizona border. Two recent surveys for *Euderma* occurred during 1983 (Fenton et al. 1987) and 1991; I completed a survey for spotted bats in the Abajo Mountains, Monticello Ranger District, Manti-La Sal National Forest (MLNF) during the 1991 field season. Both of these surveys employed the widely recommended echolocation technique (Belwood pers. comm., Navo pers. comm., Fenton pers. comm.). This technique is still evolving and is complicated by the following facts:

1. Most bats have the ability to make communicative sounds within the range of human hearing (heretofore audible), which is typically less than 20 kilohertz (kHz), while few bats use audible echolocation for orientation. It is important to recognize the difference between echolocation used for communication and orientation.

2. In the western United States there are up to five species of bats which partially or wholly use audible echolocation, and one species which sometimes audibly communicates with conspecifics at roosts. The distribution and abundance of all of these species is not well known.

3. Four of these audible/semi-audible species are considered rare.

The U.S. Fish and Wildlife Service (USFWS) considers *Euderma*

maculatum as a Category 2 Candidate for listing as Endangered or Threatened. Additionally, the Utah Division of Wildlife Resources (UDWR) considers the spotted bat to be sensitive within Utah. Likewise, the Utah Heritage Program (UTHP) recognizes this species as rare and applies a rank of G4S1. The USDA Forest Service (USFS) Region 4 has included this species on the Region 4 Sensitive Species List.

This report addresses the objectives and findings of two Cooperative Challenge Cost Share projects between the USFS Manti-La Sal National Forest and the UTHP, and the USFS Fishlake National Forest (FNF) and the UTHP.

OBJECTIVES

The 1992 Cooperative Challenage Cost Share agreements called for the the UTHP to complete the following objectives:

1. Gather and summarize existing knowledge about *Euderma* and devise a field workplan.

2. Conduct field inventories at locations determined from this workplan to locate new occurrences of spotted bats.

3. Where spotted bats are found, collect locational and habitat data.

4. Make suggestions concerning future survey needs.

STUDY AREA

Manti-La Sal National Forest

Rod Player, MLNF Forest Biologist, requested the general area to be surveyed as selected areas on the Ferron Ranger District, and the lower portion of Huntington Canyon, Price Ranger District, along the east side of the Wasatch Plateau. The Wasatch Plateau occurs along the eastern line of the Utah High Plateaus, bordering lower canyon country of the Colorado Plateau physiographic province to the east.

Ferron Ranger District:

The specific survey routes on the Ferron Ranger District were determined on site with District biologist Cindy Burns, MLNF. Some of these areas have experienced past or on-going impacts from mining (subsidence).

Cottonwood Canyon

The Cottonwood Creek Road survey route extends from just above the Trail Mountain Mine approximately 5 1/2 miles upstream to the

East Mountain/Mill Canyon road turnoff (T17S R6E Sections 25, 24, 23, 14, 11, 10, 3, and 2). The canyon is slightly wider and less steep than both Huntington and Straight canyons. Additionally, there are few rock outcrops and cliffs present in this canyon. Elevations along the survey route range from 7400 ft to 8400 ft. The habitat ranges from pinyon-juniper (*Pinus edulis - Juniperus osteosperma*) and cottonwoods (*Populus spp.*) along the mostly dry intermittent stream near the mine to mixed-conifer and aspen (*Populus tremuloides*) above. Canopy cover ranges from less than 25 percent to 50 percent in some areas of the canyon. Vehicle traffic in the canyon was minimal during the survey period.

Newberry Canyon

The Newberry Canyon survey area includes one site at the mouth of the canyon, below the Wilberg mine (T17S R7E Section 34). The elevation is 7000 ft. The habitat is predominantly pinyon-juniper, and the only water present is a low flowing creek from the Wilberg Mine area. This site was included to determine whether *Euderma* might be using an area impacted by mining subsidence.

Quichupah Creek

The Quichupah Creek survey area includes one site at T21S R5E Section 32 SE4. Access to this area required traveling through the Convulsion Canyon Mine to a site in Quichupah Creek to determine whether *Euderma* might be present in a potential longwall mine which could be impacted by subsequent subsidence. The canyon is narrow with cliffs bordering the upper slopes. The elevation is 7000 ft. Coniferous trees are present on steep slopes. The creek is medium to fast flowing, making some noise.

Straight Canyon

Surveys in this area occurred along the Straight Canyon road, from the National Forest boundary upstream to Joe's Valley Reservoir (JVR) (T18S R6E Sections 12, 11, 10, 2, 3, 4, and 5). Straight Canyon is relatively narrow with tall cliffs on the northside, and steep, rocky slopes forested by conifers on the southside. The elevation ranges from 6400 ft to 7000 ft. Canopy cover ranges from less than 25 percent to 75-100 percent. The creek is fast flowing and noisy. At the head of the canyon is the Joe's Valley Reservoir dam. The road through Straight Canyon is busy with recreational vehicle traffic, even into the early morning hours (2:00 a.m.).

Price Ranger District:

Huntington Canyon

The survey route in Huntington Canyon begins at the National Forest boundary near the mouth of the canyon and extends along the road to the Electric Lake area (T16S R7E Sections 22, 15, 16, 10, 9, 4, 5; T15S R7E Sections 33, 32, 29, 20, 17, 8, 5, 6; T14S R7E

Sections 31, 30; T14S R6E Sections 24, and 13). The elevation range of the survey area is from 7000 ft to 8500 ft. The lower portion of the canyon was emphasized. The habitat ranges from pinyon-juniper at the mouth of the canyon to ponderosa pine (*Pinus ponderosa*) and fir (*Abies spp., Pseudotsuga spp.*) near the head of the canyon. Canopy cover ranged from less than 25 percent to nearly 90 percent. Cottonwoods line the creek throughout the lower half of the canyon. Huntington Canyon is relatively narrow. The topography ranges from large, vertical cliffs with talus near the mouth of the canyon to smaller fragmented cliffs and steep slopes near the canyon head.

Huntington creek is fast flowing and noisy. The road in this canyon is extremely busy with double trailer coal truck traffic throughout the night, from the town of Huntington up to the coal mine. The trucks speed through the canyon, making it very difficult to pull of the road safely and listen for bat vocalizations. At one survey stop, nine coal trucks passed within a 15 minute period.

Fishlake National Forest

Kreig Rasmussen, FNF, requested that the study areas include a survey route near Snow Lake on the Loa Ranger District, and the Old Woman Plateau, Richfield Ranger District, to be selected later during a meeting at the beginning of August 1992.

Loa Ranger District:

Snow Lake

The Snow Lake survey area occurs along USFS Road 209 that bisects the Snow Bench and Deep Creek Timber Sale Areas (T27S R4E Sections 22,27, and 34). Elevation is approximately 10,000 ft. The habitat contains mostly mixed-conifer with some aspen and small lakes, and is bordered by steep canyons and cliffs to the east. Canopy cover ranges from less than 50 percent in logged areas to 90 percent in unlogged areas. Vehicle traffic and flowing water noise do not plague this area.

Richfield Ranger District:

Survey routes on the Richfield Ranger District include Little Duncan Mountain, Jack Adley Monument and Corral Knoll, northeast of Accord Lakes north of I-70.

Little Duncan Mountain/Corral Knoll/Jack Adley Monument

The Duncan Mountain/Corral Knoll survey route begins from the ridge-pass to the north of Duncan Mountain, heads south along USFS Road 007 to Little Duncan Mountain and continues southeast along USFS Road 268 beyond Corral Knoll (T21S R5E Section 31; T21S R4E Section 36; T22S R5E Sections 6,5 and 8). The survey route to the Jack Adley Monument occurs from approximately 1 1/2 miles south of

USFS 268, along USFS Road 007 and heads southeast along USFS Road 267 (T22S R4E Sections 1 and 2).

This survey area is located along the southeast rim of the Wasatch Plateau and is bordered by steep rocky canyons. The habitat on top of the plateau consists of mostly open rolling terrain which rises from 8400 ft to 9300 ft. Patches of mixed-conifers occur toward the plateau's rim. Water is present in small shallow ponds approximately 1 mile southwest of Jack Adley Monument, and adjacent Quichupah Creek.

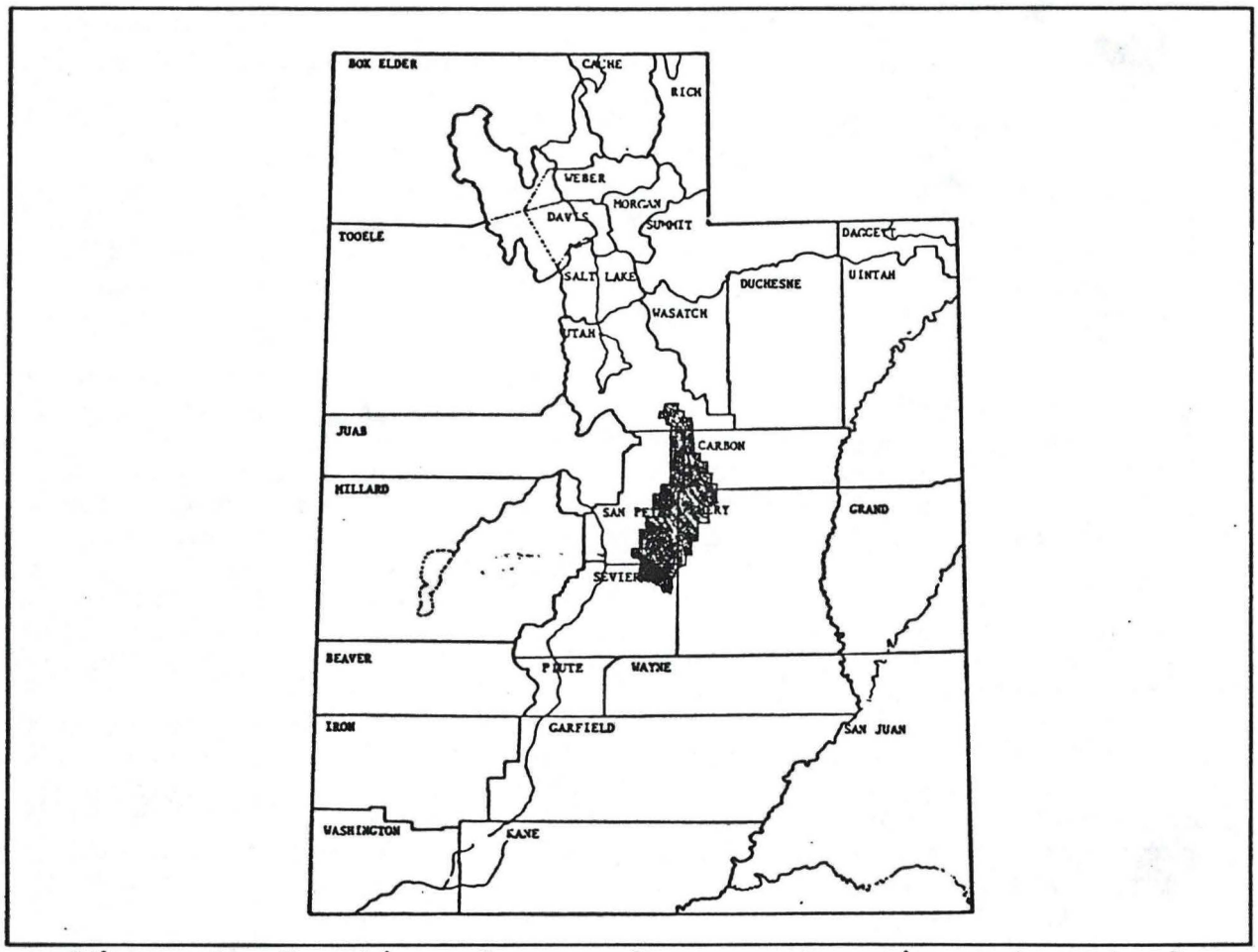

Figure 1. Location of general survey area in east-central Utah.

METHODS

As outlined in the UTHP - MLNF and FNF Cooperative Challenge Cost Share workplans, this report provides a summary of the existing information and data collected for *Euderma* on the MLNF and FNF during the 1992 field season, August through early September.

Existing information was obtained from museum records, literature, and personal communications with knowledgeable individuals. A list of personal communications is included following the "Other Literature" section.

Analysis of existing information provided a preliminary indication of the potential habitats in which *Euderma* is most likely to occur: desert shrub to subalpine conifers, riparian areas and river canyons with cliffs nearby. These were the habitat types emphasized during this survey.

Survey Methods

Since results from my 1991 Abajo Mountains survey show that many audible bats were present in that study area and due to the subsequent review of supplementary information, there does not appear to be a great distribution overlap of audible bats (*Euderma, Idionycterus (Plecotus) phyllotis* [Allen's big-eared bat, and *Nyctinomops macrotis* [big free-tailed bat]) in the 1992 study area. There is one 1975 record of *N. macrotis* north of the 1992 study area. Consequently, the survey methods used for spotted bats were based on those described in Wai-Ping and Fenton (1989) and required listening for spotted bat audible echolocation sounds.

Fenton (pers. comm.) and Belwood (pers. comm.) recommend listening for spotted bat sounds rather than mist-netting, even if a bat detector is not available to monitor bat vocalizations. A bat detector is a device which converts incoming ultrasonic bat vocalizations to audible sounds and displays the frequency. Thomas and LaVal (1988) suggest that bat vocalizations can be used to determine relative abundance. However, this technique can be biased depending on the type of device used and whether the calls are of high or low frequency (Kunz and Brock 1975). Since a bat detector was not the primary instrument used in this survey, biases from this technique are irrelevant.

Wai-Ping and Fenton (1989) divided spotted bat echolocation sounds into two categories: a "bat pass" represented by echolocation at a constant rate, and a "foraging buzz" represented by echolocation at an increased rate. The foraging buzz occurs while the bat is emitting more pulses per unit time to pinpoint the location and type of insect being pursued. During the present study, the number of spotted bat passes and foraging buzzes heard were counted during one 15 minute interval per site per night, with two repetitions at all sites except for Quichupah Creek, MLNF. Spotted bat echolocation sounds can be heard up to a distance of 0.25 km (0.15 miles). Consequently, sites were placed at least 0.50 km (0.30 miles) apart. Since many audible bats were encountered during my 1991 Abajo Mountains survey, the distance between survey stops was increased to 0.8 km (0.5 miles) to cover more area.

Merlin Tuttle (Bat Conservation International) claims that all bats change their activity with lunar phases (pers. comm. to Ken

McDonald, UDWR). However, in a study in British Columbia, Wai-Ping and Fenton (1989) found that spotted bat activity is not influenced by time of night, weather conditions or lunar phase. Considering these parameters, sites were surveyed throughout the night and during any lunar phase. Although Wai-Ping and Fenton (1989) standardized their surveys by sampling between dusk and 0230 hours, this survey was conducted from dusk to dawn to make the best use of time. Heavy rains and strong winds decreased the quality of hearing, so the survey was not conducted during these conditions.

Mist-netting was accomplished in cooperation with Bill Bates (UDWR), Cindy Burns, and Brad Lengas (Ph.D. candidate, Utah State University). Approximately 15 hours were spent netting over a period of four nights. Netting was conducted in association with Bill Bates or under the permit of Brad Lengas.

The QMC II Mini Bat Detector (Ultra Sound Advice, 23 Aberdeen Road, London, N52UG, U.K.) was used on one occasion during this survey. The instrument receives sound waves from 15 to 160 kilohertz, plus or minus 1 kHz, but the dial has increments from only 20 to 160 kHz. Consequently, any reading below 20 kHz must be approximated.

Initially, I became familiar with spotted bat echolocation sounds by listening to a cassette recording provided by Kirk Navo and Brock Fenton. I also visited Fort Pierce Wash near St. George, the most active spotted bat site known in Utah, to compare the cassette recording with actual spotted bats calls from a known location.

Data Collection

From the 1991 Abajo Mountains study, I learned that in the southern quarter of Utah there are at least three species of audible bats. Since a sophisticated bat detector (see the Echolocation Survey Equipment and Techniques section for an explanation) was not available for the project, a written description of bat echolocation pulses as they sounded to me, were logged on data sheets. The number of audible bat passes was recorded for each survey interval (15 minutes/stop).

Field data for MLNF and FNF are located in Appendices 1 and 2, respectively. Maps showing all survey routes, except for the Newberry Canyon site, are included in Appendix 3 (MLNF) and Appendix 4 (FNF). Photographs of the survey routes for both Forests and spotted bat museum specimens are included in Appendix 5. Additionally, at some sites where audible bats were located, recordings of the calls were attempted using the MLNF's Marantz PMD 221 tape recorder.

DISTRIBUTION

Spotted bats are widely distributed in relatively low numbers throughout western North America, from southwestern British Columbia to Mexico. Figure 2 shows the distribution of spotted bats in the United States. Poche (1981) mentions that there are only three known areas in the southwestern United States where spotted bats can be captured with regularity, and that the Fort Pierce Wash area in Warner Valley, Washington County, Utah may support the largest of the three populations.

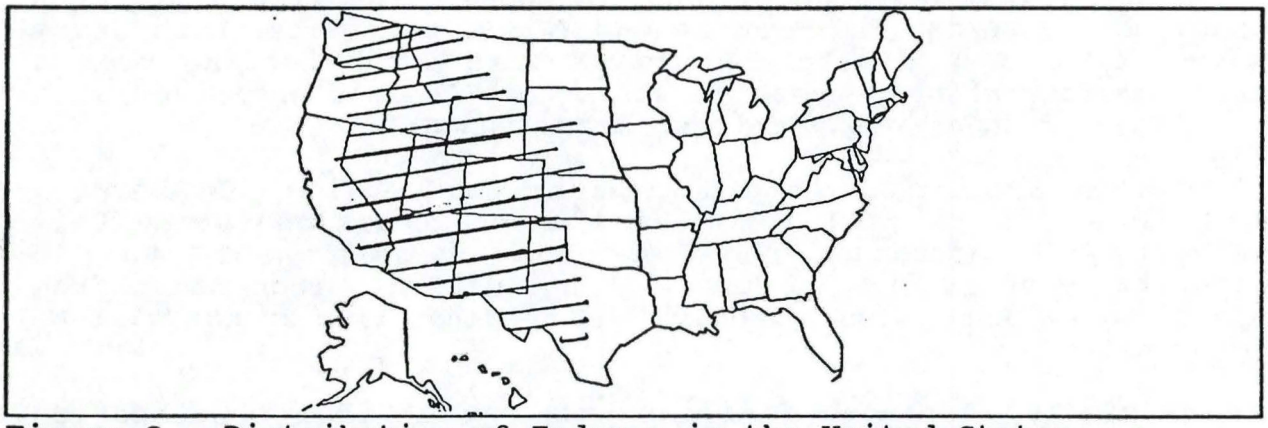

Figure 2. Distribution of *Euderma* in the United States.

Specimen records were obtained from museum collections at Weber State University (Jenne pers. comm.), University of Utah Museum of Natural History (Eric Rickart pers. comm.) and Brigham Young University (Skip Skidmore pers. comm.), and are summarized in Appendix 6. In Utah, *Euderma* is known from the following counties: Garfield, Grand, Kane, Salt Lake, San Juan, Utah, and Washington. Additionally, Ken McDonald (pers. comm.), states that a spotted bat was found in a window sill of a Cedar City home in Iron County. There is rumor of one potential collection from Davis County (Jenne pers. comm.), but this could not be confirmed. Figure 3 displays the distribution of *Euderma* in Utah.

Additionally, only three field surveys targeting *Euderma* have been conducted in Utah. These include my 1991 and 1992 surveys, and the effort of Fenton et al. (1987) to locate spotted bats in 1983. In my 1991 Abajo Mountains survey, so many more audible bats were heard than expected, that I concluded from the information I had at the time that a combination of *Euderma*, *Tadarida brasiliensis* (Brazilian free-tailed bat), and *N. macrotis* were probably detected. In light of new information, this is probably not the case, as discussed in detail later in this report. Fenton et al. (1987) relocated *Euderma* at the Fort Pierce Wash site southeast of St. George, near the Temple of Sinawava in Zion National Park, and near Widtsoe Junction west of Escalante. Further, Fenton et al. (1987) searched for *Euderma* in other areas

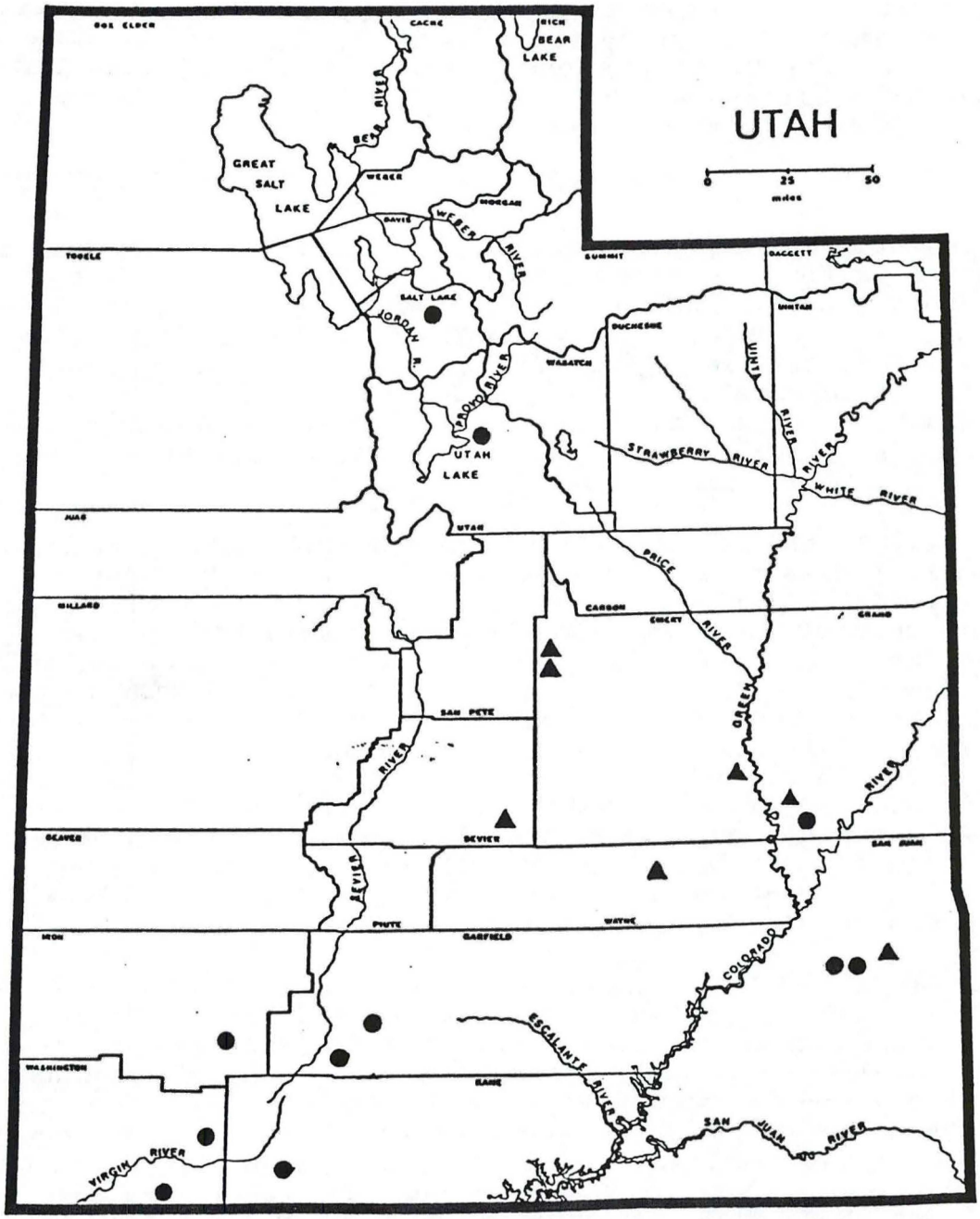

Figure 3. Distribution of *Euderma* in Utah from museum and published records (●), and from locations where they have been audibly detected (▲).

of Garfield and Washington Counties, and in Sanpete County, where spotted bats were not located.

Spotted bats have been recently located during two other general bat surveys in southern Utah. In 1991, Dana Shertliff (BYU, pers. comm.) captured spotted bats at the Fort Pierce Wash site. During a 1991 survey for bats in Capitol Reef National Park, Mike Bogan (USFWS, pers. comm.) found a spotted bat which had drowned in a slickrock pool.

SPECIES DESCRIPTION

Spotted bat body measurements include a total length of 107 mm to 125 mm, a forearm length of 48 mm to 54 mm, a tail length of 46 mm to 55 mm, a hindfoot length of 9 mm to 12 mm, an ear length of 39 mm to 50 mm, and a tragus length of 13 mm to 17 mm (O'Farrell 1981). O'Farrell claims that females tend to be larger than males, but the difference is not significant. Spotted bats are slow-flying bats with a low Aspect Ratio (wing span [cm^2]/wing area [cm^2]) of 6.6, and a low Wing Loading Ratio (weight [g]/wing area [cm^2]) of 0.0804 (Poche 1981).

Zeveloff and Collett (1988) remark that spotted bats are one of the most bizarre-looking mammals in the world. They are black dorsally with three large circular white spots on the shoulders and the base of the tail, and white patches at the posterior base of the auricles. Ventrally, spotted bats have white fur which is black basally. On the throat, there is a bare, non-glandular patch. Poche (1981) suggests that this may function for conductive heat exchange during high ambient temperatures. The ear, wing, and tail membranes are pinkish-red. The ears are the longest of any bats in North America. Additionally, the ears are upright while active, but when the bats are in torpor the ears curl back, resembling a ram's horns (O'Farrell 1981). Photographs 1 and 2 (Appendix 5) show spotted bat specimens from the University of Utah's Museum of Natural History.

O'Farrell (1981) discusses the specialization and relict species status of spotted bats. Handley (1959, in O'Farrell 1981) suggests that spotted bats are the most specialized species within the plecotini group. Spotted bats are the only species that can effectively locate tympanate moths which have thoracic ears that can detect bat ultrasounds, usually those of higher frequencies. Tympanate moths use this ability to avoid predation from bats, but can not escape spotted bats. O'Farrell (1981) defines relict species as those that have become geographically and ecologically restricted as a result of ecological processes, and survive in patchy environments which were formerly widespread. Specifically, O'Farrell (1981) suggests that the specialization of spotted bats to exploit tympanate moths was influenced by competitive pressure which now provides *Euderma* with an advantage.

Euderma maculatum is the only member of its genus. Morphologically there are no other species in Utah with which spotted bats could be confused. However, there are three genera of bats in Utah which use vocalizations for orientation that can be possibly detected by the unaided human ear: *Euderma, N. macrotis* (Fenton pers. comm.), and *I. phyllotis* (Findley and Jones 1965, Simmons and O'Farrell 1977, Fenton pers. comm.). Additionally, there is some existing evidence that some populations of *T. brasiliensis* partially echolocate within our hearing range (Navo pers. comm.). All of these species are discussed in more detail later.

LIFE HISTORY

Reproduction

Much of the data collected regarding spotted bats are preliminary and have dealt with distribution and habitat-use. Consequently, most published life history information has been extrapolated from the breeding condition of captured individuals, and is often ambiguous. For example, Easterla (1965, 1973) caught male spotted bats in Texas during the late summer which had enlarged testes, indicating that copulation probably takes place during the fall and parturition occurs during the spring after delayed implantation, not unlike many other bat species. Further, Easterla (1965) reported capturing 3 lactating females in August, so parturition may occur as late as July. Additionally, Fenton (pers. comm.) observed that spotted bat activity appeared to change for a week or so during late summer, and suggested that this may be the breeding season. Poche (1981) found mature spermatozoa in an individual caught during the spring, which also indicates that, in contrast to Easterla (1965, 1973), spotted bats may actually breed during late February or early April, with parturition occurring in May or June.

Spotted bats appear to give birth to one altricial young, weighing about 4 g (Easterla 1971). Further, it appears that spotted bats do not congregate in nursery colonies as do other bats, but remain solitary throughout the year, except for small groups found during torpor, or hibernation (Easterla 1965).

GENERAL ECOLOGY

Associated Species

During the summer of 1991, Shertliff (pers. comm.) netted spotted bats at Fort Pierce Wash in association with the following species: western pipistrelle (*Pipistrellus hesperus*), Brazilian free-tailed, big free-tailed, pallid (*Antrozous pallidus*), and big brown (*Eptesicus fuscus*) bats. Also in the Fort Pierce Wash area, Poche (1981) captured western pipistrelles, Mexican (Brazilian) free-tailed bats, pallid bats, and California myotis (*Myotis*

californicus) with spotted bats during the winter, and observed Townsend's big-eared bats (*Plecotus townsendii*) and pallid bats in caves; spotted bats were not found in these caves.

Few netting efforts have been accomplished in or near the 1992 MLNF and FNF study areas. According to Hasenyager (1980), two specimens captured in or near the study areas were the long-legged myotis (*Myotis volans*) and the big brown bat. Other recent records include the location of Townsend's big-eared bats in a USFS building and a mine, both on the Ferron Ranger District (Burns pers. comm.).

Foraging

Most researchers (Ross 1961, Fenton et al. 1987, Wai-Ping and Fenton 1989) have observed spotted bats foraging for large insects, primarily Lepidoptera, while in flight, but there are some published reports of *Euderma* feeding on the ground. Woodsworth et al. (1981) explain that bats using lower frequency echolocation tend to forage on larger insects. Poche (1981) estimated that spotted bats foraged 2 to 30 m above Fort Pierce Wash, whereas Watkins (1977) claims that spotted bats land, chase, capture, and feed on prey while on the ground. Poche and Bailie (1984) also observed a spotted bat feeding on a grasshopper on the ground.

Spotted bats tend to forage in individual territories, or territories which slightly overlap, using the "trapline" foraging strategy (Woodsworth et al. 1981, Leonard and Fenton 1984, Navo 1990). Fenton et al. (1987) report that at sites with greater than one spotted bat pass per unit time, *Euderma* foraged sequentially, except at one site where it seemed that approximately 20 spotted bats were active at one time. Bats with adjacent foraging areas tended to retreat if both were present simultaneously; if not, one would cross over and forage in the other's territory. However, Wai-Ping and Fenton (1989) found, using radio telemetry, that spotted bats on their study area in British Columbia had overlapping foraging areas. Wai-Ping and Fenton (1989) also report that spotted bats foraged most often over marshes and in open ponderosa pine habitat. Flight paths were elliptical, 200 to 300 m long, and advanced through the habitat by extending the ellipsoid course in a forward direction.

Some spotted bats seem to follow the same nightly flight patterns. Woodsworth et al. (1981) report that a spotted bat flew into the same clearing four nights in a row and initiated the same search sequence of the area. Researchers predicted the bat's arrival to within one minute each night. The bat usually flew about 20 m from the forest edge. Likewise, Poche (1981) observed individual bats which punctually emerged from their roosts in Washington County.

Spotted bat temporal activity, as reported in the literature, is variable. Poche (1981) suggests that spotted bats emerge from their roosts approximately 1-1/2 to 2-1/4 hours after sunset and

fly directly to water for a drink before foraging. Poche (1981) observed that the bats were most active 1 to 4 hours after sunset, with another peak about 1 hour before sunrise. Fenton et al. (1987), Navo (1990) and Pritchett (pers. comm.) report that spotted bats foraged all through the night with no apparent peaks in activity, whereas Easterla (1965) netted all *Euderma* after midnight.

Habitat

Spotted bats were originally thought to be associated with ponderosa pine forests, but recent surveys indicate that this species uses various habitat-types ranging from desert-shrubs to sub-alpine forests (Pritchett pers. comm., Fenton pers. comm.). Poche (1981) contends that the most critical factor is the presence of cracks and crevices of the right size in limestone and the preferred sandstone rock formations. At Fort Pierce Wash, he found the bats used cracks ranging in size from 2.0 to 5.5 cm. Further, Poche checked 17 caverns and caves and did not find any spotted bats using them, although other bats were found.

Human Disturbance

The presence of humans does not appear to affect spotted bats. Fenton et al. (1987) report a major roosting area in a cliff overlooking a KOA campground in British Columbia, and Navo (1990) heard many bats near a campground in Dinosaur National Monument, Colorado.

Movements

Wai-Ping and Fenton (1989) used radio telemetry to study the ecology of *Euderma* foraging and roosting behavior in southcentral British Columbia. The researchers found that from May to July, *Euderma* were faithful to the use of roost and forage areas, and to the routes used to access and return from the foraging areas. In August and September, the areas used by spotted bats became less predictable. This change may be concurrent with young beginning to forage on their own, but this aspect of spotted bat ecology has not been studied. Fenton et al. (1987) found that weather, cloud cover, wind speed, temperature, lunar phase, or time of night did not significantly influence the activity pattern of spotted bats, although there was a slight increase in activity when the ambient temperature reached 18° C.

Spotted bats have been observed moving up to 10 km from roosts or capture sites. Wai-Ping and Fenton (1989) followed radio-tagged *Euderma* which moved 6 to 10 km, straight line distance, from the roost for foraging. Except for lactating females, these bats also flew continuously while away from the roost for periods of 3 to 5 hours. The farthest tracked movement of a spotted bat from the point of capture in the Fort Pierce Wash area is 6 km (Poche 1981). Poche also caught two spotted bats and released them 24 km from the

capture site; one of the bats was recaptured one month later in the original capture location.

Population

Fenton et al. (1987) conducted a general census for western bats using bat detectors to monitor echolocation calls. Researchers found that in relation to the other bats detected, spotted bats were indeed uncommon. Fenton et al. (1987) also suggest that over-collection of specimens negatively impacts for spotted bat populations.

Roost Sites

Wai-Ping and Fenton (1989) found that, on 63 of 64 occasions, spotted bats used the same day roosts from May to July, departed from the roosts at predictable times, but returned at various times. Departure seemed to be influenced by the time of sunset and not ambient temperature. Poche (1981) claims that the presence of water near cliffs with potential roost sites (cracks and crevices) is the most important habitat combination for spotted bats.

Seasonal Activity

Hibernation and/or torpor for spotted bats are influenced in part by climatic conditions. Spotted bats have been netted during the winter in southwestern Utah (Poche 1981, Rickart pers. comm.). The coldest temperature at which Poche (1981) captured a spotted bat was -5° C (23° F). Poche claims that the bat was a resident hibernating (or torpid) individual. Both Rickart and Poche speculate that spotted bats emerge from torpor to obtain water. Since bats need sufficient water during the winter, they seek hibernacula with high humidity. The Fort Pierce Wash site lacks these qualities, so the bats are likely to be aroused from hibernation/torpor for water. This site also occasionally warms up during the winter, influencing the emergence of insects and in turn providing the opportunity for spotted bats, or other bats, to feed.

The migration of spotted bats has not been studied. It is unknown whether the species migrates locally, remains resident and hibernates, or is a long-distance migrant (Fenton pers. comm.). Poche (1981) concludes from his Fort Pierce Wash study that spotted bats primarily inhabit xeric areas but occasionally wander into higher elevations to escape summer heat. Additionally, Berna (1990) observed that spotted bats were present in higher elevation coniferous forests and then at lower elevations later in the summer, which may indicate local migration. During October 1992, I heard and recorded a spotted bat that was foraging over a wetland area near Hanksville, Utah, during a time when bats generally were not observed or heard in Moab and areas of the San Rafael Reef. By this late in the season, most bats were probably hibernating or had migrated.

Social Organization

Spotted bats do not appear to have much social organization. Individuals of this species are usually found roosting and foraging alone (Poche 1981, Fenton et al. 1987), but can occasionally form small groups while foraging and during the winter. For example, Easterla (1965) reports a group of four spotted bats in a cave in Kane County, which have not been found on subsequent visits. Both Fenton et al. (1987) and Poche (1981) report hearing many spotted bats foraging together at the Fort Pierce Wash site. The reason for spotted bats congregating at this site and not at others is unknown.

OTHER AUDIBLE AND SEMI-AUDIBLE BATS IN UTAH

There are five species of bats in Utah that are considered to echolocate either completely or partially within the range of human hearing for orientation. Another species audibly communicates. These include: *Euderma*, *I. phyllotis* (Allen's big-eared), *P. townsendii* (Townsend's big-eared), *N. macrotis* (big free-tailed), *T. brasiliensis* (Brazilian free-tailed), and *Antrozous pallidus* (pallid bat).

Euderma

1. **Audible Sounds** - According to Fenton (pers. comm.) and Navo (pers. comm.), both of whom have worked with this species, *Euderma* supposedly emits "loud metallic clicks" at a high rate of speed and completely within the capacity of human hearing. Fenton et al. (1987) report that *Euderma* echolocates in the 9 to 15 kHz frequency range. Poche (1981) reports *Euderma* frequencies ranged as high as 60 kHz, the maximum range of his equipment. Poche describes *Euderma* orientation sounds as a "click-series", which are more intense when the species approaches water for a drink. The clicks emitted during open air flight, as opposed to foraging flight, at higher altitudes (20 to 30 m) were intense but separated by longer intervals. Poche also mentions that the *Euderma* click-series seemed similar to both *I. phyllotis* and *N. macrotis* sounds, but that *I. phyllotis* had the softest sound and *N. macrotis* had the most intense.

   Since Poche made detailed observations of *Euderma* echolocation sounds in a confined and unnatural setting, it is possible that while in the field he heard some other audible bat emitting the slower paced sounds of open-air flight, which sounds similar to *Euderma*. Or, one could conclude that all the audible calls sounding similar to *Euderma* heard along eastern Utah are in fact *Euderma* echolocating at a slower pace in open-air flight.

   I recorded *Euderma* calls at a wetland site along the Fremont River just west of Hanksville, which were analyzed by Dixie

Pierson and Bill Rainey. The sonograms are displayed later in this report.

I. phyllotis

1. **Audible Sounds** - *I. phyllotis* variably echolocates within and above our capacity to hear. The sounds reported in the literature are described as loud peeps which occur at a pulse rate of about one per second and supposedly sound like *Euderma* but are lower in pitch, and rapid ticking sounds (Czaplewski 1983). Simmons and O'Farrell (1977) report that *I. phyllotis* echolocation calls typically range in frequency from 12 to 24 kHz, with harmonics reaching 40 kHz.

2. **Distribution** - *I. phyllotis* ranges from the southwestern United States to Mexico (Czaplewski 1983). In Utah, it is known from San Juan County (2 specimens), and Washington County (1 specimen). Additionally, this species was captured in 1992 from Natural Bridges National Monument (Bogan pers. comm.), and Moab (an adult male during this survey).

   O'Farrell (pers. comm.) suggests that this species is slowly extending its range northward. The first capture in the United States occurred in 1957. By 1964 the species was caught in northern Arizona, and 1967 and 1968 are the first records of *I. phyllotis* in southern Utah. The lack of captures could also be due to the fact that *I. phyllotis* may be difficult to net.

3. **ECOLOGY** - The following information is from (Czaplewski 1983). **Habitat** - *I. phyllotis* primarily inhabits forested mountainous areas, from pine, fir and oak down in elevation to riparian woodlands, desert scrub, and occasionally in more arid habitats. Information on roost sites is limited, but *I. phyllotis* may possibly roost in large boulder piles. **Migration** - Seasonal movements are unknown. Sexes segregate geographically during summer months. Females form maternity roosts, and males possibly remain solitary. **Foraging** - *I. phyllotis* glean or pursue prey. This species flies well in tight quarters (personal observation).

4. **Status** - *I. phyllotis* is considered rare (Czaplewski 1983, Zeveloff and Collett 1988, Fenton pers. comm.). This species may be included on the UDWR's Native Utah Wildlife Species of Special Concern list. Bogan (pers. comm.) suggests that this species may be more widely distributed and abundant in Utah than previously believed.

N. macrotis

1. **Audible Sounds** - *Nyctinomops* echolocates with loud low-frequency clicks, or a loud piercing chattering noise (Milner et al. 1990). Fenton et al. (1987) report that *N. macrotis*

echolocates in the 17 to 25 kHz range.

2. **Distribution** - This species ranges from southern Bolivia north throughout the rest of South America, east of the Andes, and north to central Utah and Colorado (Milner et al. 1990). In Utah, *N. macrotis* is known from Millard County (1 site), San Juan County (1 site), Utah County (1 site), and Washington County (5 sites) (Hasenyager 1980). Additionally, females and immature *N. macrotis* have been captured from Arches National Park (Grand County) in 1991 suggesting that a maternity colony may be present, and individuals have been captured in Capitol Reef National Park (Wayne County) in 1991 and 1992 (Bogan pers. comm.) as well.

3. **ECOLOGY** - The following information is from (Milner et al. 1990). **Habitat** - This species apparently inhabits rugged, rocky country, and occasionally forested areas. **Migration** - Evidently this species is a seasonal migrant throughout much of its range. Maternity colonies form and roost in cracks, crevices in sandstone overhangs, and beneath slabs of lava on a cliff, also in buildings, caves, and tree holes. In Cuba they rest singly or in small groups. **Flight** - *N. macrotis* has a high aspect wing ratio which requires this bat to drop into flight (Bogan pers. comm). Additionally, they are not highly maneuverable, and Bogan suggests that this characteristic restricts *N. macrotis* to forage in open areas. However, Milner et al. (1990) mention an account of an individual that was able to take off from a flat surface.

4. **Status** - *N. macrotis* is considered rare (Zeveloff and Collett 1988, Milner et al. 1990, Fenton pers. comm.). This species may be included on the UDWR's Native Utah Wildlife Species of Special Concern list. Bogan (pers. comm.) suggests that this species may be more widely distributed and abundant in Utah than previously believed.

T. brasiliensis

1. **Audible Sounds** - Navo (pers. comm.) states that he heard an audible bat echolocating a high-pitched sound that was more quiet and slow than *Euderma*. He subsequently caught *T. brasiliensis* in his net. Navo also claims that not all *T. brasiliensis* are audible echolocators, but that there are regional differences. He claims that along the Gunnison River, Colorado, *T. brasiliensis* can be heard, but that members of the San Luis Valley, Colorado, colony have not yet been heard.

   Since Kirk Navo claims that this species audibly echolocates in some places of Colorado, on 4 August 1992 I made the trip to listen to the colony of approximately 250,000 individuals in the San Luis Valley, to use a bat detector and determine the frequency range of this species, and to seize the opportunity to hear audible bats and compare the sounds in

person with Kirk. Some vocalizations were heard while the bats were leaving the roost for the night, and on one occasion a bat emmitted echolocations in sequence. These sounded faint compared to the majority of audible calls heard in Utah, although echolocations used while leaving the roost are usually not the same type as those used during the foraging sequence. The wind was extremely strong that night, and probably carried the bats a long distance, because neither audible nor ultrasonic sounds were located with the bat detector in the area.

There is some question as to whether it was actually *T. brasiliensis* that Navo heard. O'Farrell (pers. comm.) and Simmons (pers. comm.) both suggest that *T. brasiliensis* and *N. macrotis* roost and forage together. Therefore, it is possible that *N. macrotis* was heard and *T. brasiliensis* was caught. There are no reports in the literature of *T. brasiliensis* echolocating within the capacity of human hearing (Wilkins 1989). Additionally, Fenton et al. (1987) report that some *Tadarida* species partially echolocate in the audible range, but *T. brasiliensis*, present and common in their study area, is not mentioned as an audible echolocator in their publication. I have requested Fenton's opinion about this question and still await his answer. *T. brasiliensis* may be a species with which we should be concerned during audible bat surveys.

2. **Distribution** - *T. brasiliensis* ranges from southern Oregon, Nevada, and northern Utah east to northern Nebraska and North Carolina, and south through most of central America. Its distribution in South America is not well known (Wilkins 1989). In Utah, *T. brasiliensis* is known from the following counties: Beaver (1 site), Carbon (1 site), Juab (1 site), Millard (4 sites), Piute (1 site), Salt Lake (1 site), Sevier (4 sites), Tooele (1 site), Uintah (1 site), Utah (1 site), and Washington (9 sites) (Hasenyager 1980).

3. **ECOLOGY** - The following information is from (Wilkins 1989). **Habitat** - *T. brasiliensis* uses several types of roosts including large caves, culverts, attics, and bridges. **Migration** - *T. brasiliensis* from southwestern Utah west form a unit that migrates westward and southwestward into southern California and Baja California, whereas *T. brasiliensis* from southeastern Utah east migrate into Mexico. This species has been captured during January and February in southwestern Utah. **Foraging** - This species often flies distances of 50 km or more to reach foraging areas. Clusters of free-taileds may cover up to 400 km^2 (154 mi^2), at speeds of 40 km/hr (25 mi/hr), at 3000 m + (9800 ft) altitudes. Most foraging is done at heights of 6 to 15 m (20 to 25 ft). **Colonial** - This species forms large maternity colonies, while most males remain on wintering grounds. Males that migrate roost in bachelor colonies, or if they share roosts with females, the

males roost in a separate subcolony.

4. **Status** - *T. brasiliensis* is considered common (Hasenyager 1980). However, since *T. brasiliensis* roosts in large colonies the closure of abandon mine leaves this species suseptible to dramatic population declines.

P. townsendii

1. **Audible Sounds** - *P. townsendii* emits occasional quiet sounds (20 to 90 kHz, low intensity) which barely dip into the human hearing range (Kunz and Martin 1982). The low intensity of *P. townsendii* calls coupled with the higher frequencies do not make this species a good candidate for audible bat surveys. The animal must pass very near the microphone to be located with a bat detector.

2. **Distribution** - *P. townsendii* occurs in western North America, from British Columbia southward into central America (Kunz and Martin 1982). In Utah, *P. townsendii* is known from the following counties: Beaver (1 site), Cache (2 sites), Carbon (1 site), Davis (1 site), Duchesne (1 site), Grand (1 site), Juab (2 sites), Kane (1 site), Millard (2 sites), Salt Lake (1 site), Sanpete (1 site), San Juan (3 sites), Sevier (1 site), Tooele (1 site), Uintah (2 sites), Utah (3 sites), Washington (11 sites), Wayne (1 site), and Weber (2 sites) (Hasenyager 1980).

3. **ECOLOGY** - The following information is from (Kunz and Martin 1982). **Habitat** - This species inhabits highland areas of evergreen forests, riparian, and mid-grass prairie, and roosts in caves, mines, and buildings. **Hibernation** - This species hibernates as a solitary individual or in small clusters in mines and caves near entrances or well ventilated places where it is slightly cooler. Big-eared bats appear to arouse frequently and either change position within a hibernaculum or move among nearby caves and mines. This type of activity increases the potential loss of fat reserves. **Flight** - *P. townsendii* is highly maneuverable. **Colonial** - *P. townsendii* forms maternity colonies during spring and summer in warm parts of caves, mines and buildings. These colonies break up in August. Males remain solitary.

4. **Status** - This species is considered sensitive/rare in California (Pierson pers. comm.), is on the USFS Region 4 sensitive species list, and will probably be included on the UDWR's Native Utah Wildlife Species of Special Concern list.

A. pallidus

1. **Audible Sounds** - Vocalizations that occur within the human hearing range for *A. pallidus* usually refer to communicative signals between conspecifics. *A. pallidus* usually echolocates for orientation beyond our ability to hear them (Hermanson and

O'Shea 1983). Since this species does not use audible echolocation for orientation, no more information is included.

The distribution of these audible and semi-audible species within the Intermountain West is displayed on Table 1 and Figure 1.

ECHOLOCATION SURVEY EQUIPMENT AND TECHNIQUES

Vocalization (echolocation) analysis is a recommended survey technique for detecting and identifying bat species (Fenton and Bell 1981). Since these procedures are still in the developmental stages and require specific, and expensive sound analysis equipment, the technique is not yet widely used for general bat inventories. Since some bat species have regional dialects (Navo pers. comm., Rainey pers. comm.), it is necessary to develop a local key, statewide or possibly on a smaller scale, for identifying species from their vocalizations. This initial step is a time-intensive process. However, once the equipment is in place, and a key developed, an efficient standardized inventory and monitoring program can be implemented.

Benefits to using this technique over traditional mist-netting include: (1) detecting species which are adept at avoiding mist-nets (i.e. most big-eared bats) and potential net-wary individuals from previous captures, (2) eliminating net-caused mortalities (i.e., drowning), and (3) eventually covering large areas more quickly. Additionally, echolocation surveys can occur anywhere, especially in areas where netting would be difficult. Fenton and Bell (1981) claim that an observer with sufficient training and the appropriate equipment can accurately identify 95 percent of bat species passing the microphone, even in an area with high species diversity (i.e., 10 species).

Bat echolocations used during a foraging sequence can be categorized into three separate phases: search, approach, and terminal (foraging buzz). Since 90 percent of foraging sequence pulses occur during the search phase, Fenton and Bell (1981) recommend using these as standard calls for identifying bat species during echolocation surveys. The most useful sound characteristics for analysis include pulse frequency and duration, and patterns of frequency change (sonograms).

The equipment used to develop sonograms, and determine pulse frequency and duration includes: a bat detector, a tape recorder, a sensitive microphone, an oscilloscope, and appropriate software for analysis. The specific types and combinations of these devices to be used depends on the objectives of the survey. A brief description of each piece of equipment from Fenton (1988) follows.

A bat detector is a portable device which detects the presence of bats by processing incoming ultrasonic sounds into audible sounds or a visual output. Bat detectors range from simple to complex. Simple detectors, like the QMC Mini II, are used to

Table I. Distribution of audible and semi-audible bats in the Intermountain West.

Species	Nevada	Idaho	Wyoming	Colorado	New Mexico	Arizona	Utah
Euderma (═══)	X	X	X	X	X	X	X
Idionycteris (═══)	X			X	X	X	X
T. brasiliensis (═══)	X			X	X	X	X
N. macrotis (═══)	X			X	X	X	X
P. townsendii (ALL)	X	X	X	X	X	X	X

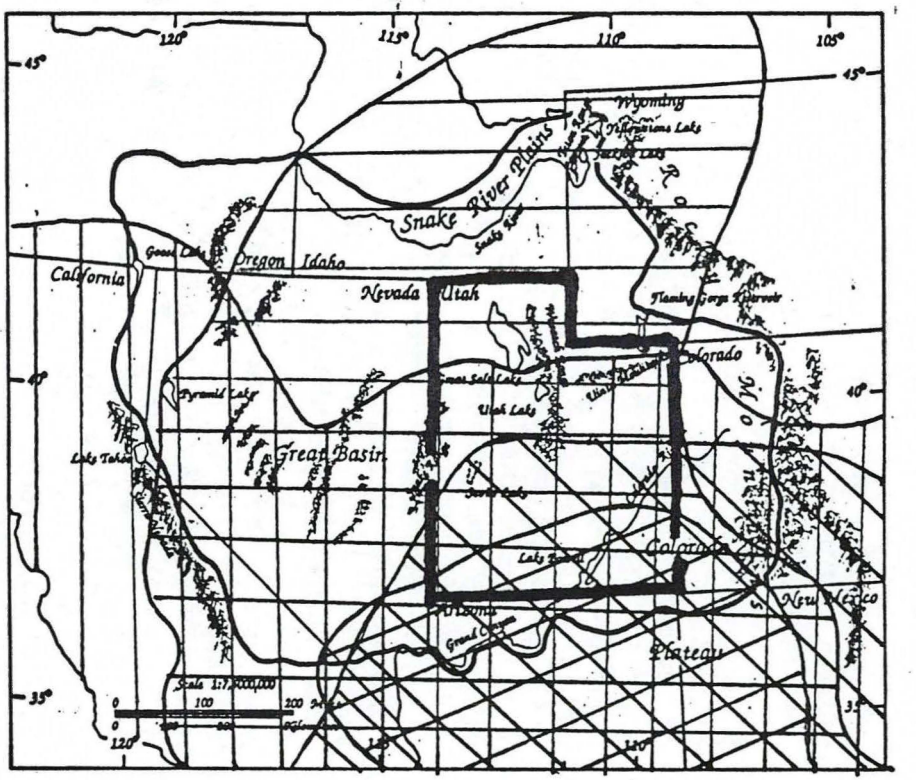

Figure 4. Distribution of audible and semi-audible bats in the Intermountain West (map from Zeveloff and Collett 1988). The key is displayed in Table 1.

locate areas of bat activity which might be good for netting or trapping, but are not very useful for species identification (Navo pers. comm., Rainey pers. comm.). Most simple detectors operate under the principal of heterodyning (i.e., the monitoring of one frequency at a time), which does not provide sufficient sensitivity toward acoustic characteristics used in producing sonograms. The production of a complete and accurate sonogram requires recording the range of frequencies emitted. Otherwise, bats emitting frequencies within similar ranges and detected at one frequency might sound or look the same on a sonogram, when in reality the pattern of the whole emission would look entirely different. Figure 3 (page 94) in Fenton (1988) illustrates this principal.

Both Fenton and Bell (1981) and information from the QMC Mini-II manual maintain that with sufficient training observers can identify bat species using the Mini II. However, the reliability of the identification would not be supported with physical evidence (sonogram).

In addition to producing audible representations of ultrasonic sounds similar to those from simple bat detectors, the more complex or sophisticated detectors are used to distinguish different species and analyze vocalizations. Sophisticated detectors, like the QMC S-25, perform a multitude of functions including the ability to monitor and display frequencies of incoming sound waves with maximum sensitivity, and reduce the incoming frequencies to levels which can be recorded on an ordinary tape recorder. Bat detectors which reduce incoming frequencies are known as "divide-by" or "countdown" detectors. A variety of factors (4,8,10, and others) are used in the reduction process. For example, incoming frequencies of 190 to 200 kHz using a divide-by 10 detector would be reduced to 19 to 20 kHz. Some acoustic information (i.e., details of sound pressure levels and harmonics) is lost, but this does not interfere with the important acoustic components: pulse frequency and duration, and patterns of frequency change.

The quality of recorder and microphone depends on the type of bat detector and the frequencies to be recorded. As previously stated, the most complex detectors can reduce the frequency to one which can be recorded on an ordinary recorder. Tape speed is an important consideration for recorders used (i.e., at 38 cm/sec the bandwidth extends to 30 kHz, 76 cm/sec reaches 150 kHz, and 152 cm/sec ranges to 300 kHz). Less complex detectors require sensitive microphones (broadband condenser types) in conjunction with a recorder of appropriate speed.

An ocilloscope provides an instantaneous display of incoming sound waves. This allows the researcher to identify species in the field without recording and processing the sounds into a sonogram, provided a key has already been developed.

To develop a local bat identification key, it is necessary to correlate the bat call received on the detector with the individual bat. Some questionable associations have been made between audible

bat sounds heard in an area and the species captured in nets. There is some margin of error using this type of association. Accurate associations can be accomplished by either of two methods. First, incoming bat vocalizations can be followed with the detector and recorded as the bat flies into a mist-net, to make a positive identification of the species. Second, bats can be captured, marked with reflective material (bands,tape or powder) and followed with a spotlight and detector while recording.

However, it is possible that either of these two methods might not detect a bat during the search phase (i.e., when the best acoustic recordings or readings can be obtained). For example, there is no mention in the literature whether bats continue to search for prey under the conditions where they are most often caught (i.e., as they approach water for a drink), although Poche (1981) describes the clicks of *Euderma* as more intense while approaching water. Some researchers (Fenton and Bell 1981, Bogan pers. comm.) suggest that bats released in a darkened laboratory can be recorded, but not all bats will echolocate or search under these unnatural conditions. Simmons and O'Farrell (1977) reported that *I. phyllotis* did not act the same under these conditions. This was also observed during the present survey, as I brought *I. phyllotis* into a room for recording. The bat flew but did not echolocate, and nothing was received on the bat detector. The technique is still in the developmental stages, and finding the best way to record the search phase is a part of that process.

Additionally, developing a key is a time-consuming process, since some bats are more difficult to net than others. Other factors inhibiting this process are recording and detection interruptions from noises, which can include rapidly flowing water (streams), wind, and vehicle traffic. For example, the only occasion a rapidly echolocating audible bat was heard at Joe's Valley Reservoir coincided with the passing of two trucks. Consequently, the recording opportunity was lost. Some equipment can be used to decrease the amount of background noise, but I need to research this further.

1992 SURVEY RESULTS

Audible bat passes were detected at 24 percent and 93 percent of survey stations on the MLNF and FNF, respectively. *Euderma* vocalizations were likely heard at two sites on the MLNF and at one site on the FNF. The term "likely" is used since identification was not confirmed by netting or a bat detector. The audible sounds heard during this survey were as confusing as the ones detected last year (1991 Abajo Mountains survey), since many of the calls resembled the pre-recorded spotted bat vocalizations but occurred at slow pulse rates. On the occasion that I had the QMC Mini II bat detector, the audible calls ranged from below 20 kHz on the detector's dial to approximately 25 kHz. Most audible bats were first heard at dusk. Detailed survey results for each Forest are presented below.

Many audible bats were heard in the valley towns south of Price along Highways 10, 6, 191, and 24, and at the Coral Pink Sand Dunes State Park and the north rim of the Grand Canyon, Arizona. Since many audible bats and their different sounds (through my interpretation) were heard during this survey, their calls were grouped into three categories: loud/fast (LF), loud/slow (LS), and high-pitched/faint (HP).

Four mist-netting attempts were made to discover which audible or rare bats were present. Two sites were associated with actual or potential study areas, and the other two sites were characterized by high audible bat activity and good netting conditions (isolated water sources). Neither audible nor rare bats were captured in association with study areas. The two sites not associated with the study areas were in Wellington (Carbon County) and Moab (Grand County). On 8 September, netting was attempted over a small pond in Wellington. However, on this night the ambient temperature was cooler and only three bat passes were heard. Bats were not captured on this occasion. It seemed that the audible bats may have migrated or begun hibernating, depending on the species.

On an unrelated visit to Moab in mid-September, many bats were heard. Consequently, one last trip was scheduled for 28 September to make recordings and net in Moab. Again, many bats were heard foraging throughout the town of Moab and near the mouth of Mill Creek, the netting site southeast of town. Interestingly, an *I. phyllotis* was caught. The *I. phyllotis* was released in a motel room and recording was attempted. However, the bat did not echolocate while in the room; the bat detector did not receive any signals.

After attempting to record, the bat was then banded with reflective tape and released. A spotlight was used to follow the bat, and a bat detector was used to monitor its activity. The bat flew out of the detector's range, but was picked up again by the bat detector as the bat made a pass through the area. When the reflection observed in the spotlight revealed the *I. phyllotis* previously caught, the bat detector was immediately turned off to hear the audible component of the bat's call. It sounded like low frequency clicking but less loud than that of the spotted bat. This clicking was heard earlier in the area, indicating that at least two *I. phyllotis* were present in the area. I did not hear loud peeps emitted from this bat, so I cannot conclude that the majority of audible bats heard in Moab were this species or not.

Recording opportunities were lost at all study area sites. The recording of bat sounds was negatively affected by the noise generated from the creeks and vehicle traffic and the sporadic arrival and departure of audible bats. Consequently, recordings were attempted at other sites where similar sounding bats were heard (Moab, Hanksville, and the Grand Canyon). The best recording of these audible bats was made in Moab. Unfortunately the tape containing these recordings mysteriously disappeared.

Consequently, the only recordings analyzed were those from the Grand Canyon and Hanksville. The Grand Canyon bat vocalizations resembled the audible bats heard over the past two field seasons in Utah, but sounded slightly lower in frequency and slower in pulse rate to me. According to Dixie Pierson and Bill Rainey (pers. comm.), the sonogram and actual sound of the recording closely resembles the calls of *Eumops perotis*, a species of free-tailed bat occurring in Arizona and California, and seemed to have a different dialect than what Pierson and Rainey are familiar with in California.

The sound and sonogram of the Hanksville recording most resembled Fenton's and Navo's cassette recordings and published sonograms of *Euderma*. This bat sounded like what I expected from *Euderma*. The tone sounded similar to the audible bats heard all over eastern Utah, except the pulse rate was much faster. Bill Rainey provided some 2-D sonograms of the recordings which are displayed in Figures 5,6, and 7 at the end of this section. These are not prepared to publication standards either in terms of the sampling rate used or the output format, but provide a cursory view of the differences between the calls of *Euderma* and *Eumops*. Figure 5 shows four selected *Euderma* pulses on the same time scale as the *Eumops* calls (Figure 6) to show the differences in the time/frequency relationships. Figure 7 shows a 10-second segment of the *Euderma* signal displaying both the frequency and intensity variation and the almost metronomic pattern of the call which some people liken to a ticking clock (Rainey pers. comm.).

Manti-La Sal National Forest

During the 1992 field season, 49 audible bat passes were detected at 24 percent (7/29) of the survey stations in three of the five MLNF study areas. Ninety percent of these bat passes were heard in Straight Canyon. Spotted bats were "likely" heard in two areas on the MLNF, one of which was not part of the formal study area: JVR/Straight Canyon, and at the Fish Creek Mine site near Ferron Canyon.

Ferron Ranger District:

Before the Ferron Ranger District sites were determined, Cindy Burns, Bill Bates, Scott Richardson, and Julie Novick (UDWR seasonal) and I netted at the Fish Creek Mine Site (near Stevens Creek) on 12 August 1992. Three bats were netted, two at the mine entrance and one at the creek, and tentatively identified as *California myotis*. Three LF bat passes were heard while netting, but no audible bats were captured.

Cottonwood Canyon

Out of 9 survey stations, audible bat passes were not heard at any of the stops. This drainage is characterized by few rock outcrops, and very low intermittent stream flows.

Newberry Canyon

Only one station was surveyed at this site. This site was surveyed to determine the presence of spotted bats in an area impacted by subsidence (longwall mining and the subsequent collapse of a cliff wall). No bats were heard.

Quichupah Creek

On 13 August, netting was accomplished at one site along Quichupah Creek, with Bill Bates, Scott Richardson, Cindy Burns, Wes Sorenson (Convulsion Canyon Mine Company) and I. Audible bats were heard on two occasions over the two hour netting period, but none were captured. Although this creek was small relative to Straight Creek and Huntington Creek, the amount of flow generated much noise, making it difficult to hear audible bats. Due to the inaccessibility of the site (obtaining a ride through the mine), and the little bat activity observed, this site was not revisited.

Straight Canyon

Most of the audible bat passes (90 percent) were heard in this canyon, and most of the Straight Canyon bat passes (85 percent) occurred at the top two survey stations (8,9), at the JVR dam. It was difficult to determine how many spotted bat passes were actually heard at these stations. At stations 8 and 9, a total of 12 and 16 bat passes were heard, respectively. It sounded as if many audible bats were simultaneously foraging at both of these stations. Consequently, some of the bats may have been emitting LF calls, while others were making the similar-sounding LS calls. It is equally possible that enough bats were present that many simultaneously emitted LS calls sounded fast, like LF. However, two bats, one right after the other, were definitely heard emitting LF calls. Bat passes were also heard at three other stations in this canyon. The number of passes per site ranged from 1 to 3.

Tall cliffs border this canyon on the northside and may provide suitable roost sites for any of the audible bat species. However, the only way this can be determined is by using radio telemetry.

Although the recording equipment was able to record sounds from a distant hooting owl at JVR, the bat sounds would not record. Additionally, the two "likely" spotted bat passes were heard coincident with the passing of two vehicles, causing inadequate recording conditions.

Price Ranger District:

Huntington Canyon

Surveys were first attempted at this site on 6 August, after the trip to Colorado to listen to *T. brasiliensis*. The first two stops were surveyed, but after that I quit for the night due to

heavy rain, hail, thunder and lightning in the canyon. Surveys were resumed at a later date. Coal truck traffic was extremely heavy (9 trucks passed during one 15-minute period), making it unsafe to pull off the road onto small turnouts and also very noisy. Consequently, the distance between survey stops depended on the location of large turnouts. Additionally, the loud sound of the creek made it difficult to hear bats.

Out of nine survey stops, two audible bat passes were detected at station 7. These vocalizations sounded high-pitched with increased repetition rates (possibly *Euderma*). This call did not exactly fall into the LF category, but this may have been a function of the noisy conditions.

Most of the cliffs associated with this canyon occur at the mouth and continue downstream. Few cliffs occur upstream.

Fishlake National Forest

On the FNF, 62 audible bat passes were detected at 93 percent (15/16) of the survey stations, in all three FNF study areas. The number of bat passes per station were relatively well distributed between stations. The number of bat passes per station ranged from 1 to 9 (mean = 2). *Euderma* was heard at Snow Lake. Due to the sporadic arrival of bats to FNF survey stations and the apparent distance of calls from the site, tape recording was not successful.

Both of the FNF survey areas border cliff/canyon country which could provide suitable roosting sites, with foraging possibly taking place on the forest. There may be roosting areas on the Forest but this would have to be investigated.

Loa Ranger District:

Snow Lake

Seventy percent (14/20) of calls heard along the Snow Lake survey route were HP, one sounded like *Euderma* (LF), one with a change in rate similar to the *Euderma* calls but did not sound like *Euderma* recording, and four were LS.

Little Duncan Mountain/Corral Knoll/Jack Adley Monument

Ninety-five percent (40/42) of bat sounds heard along this survey route were LS, and 2 were HP faint.

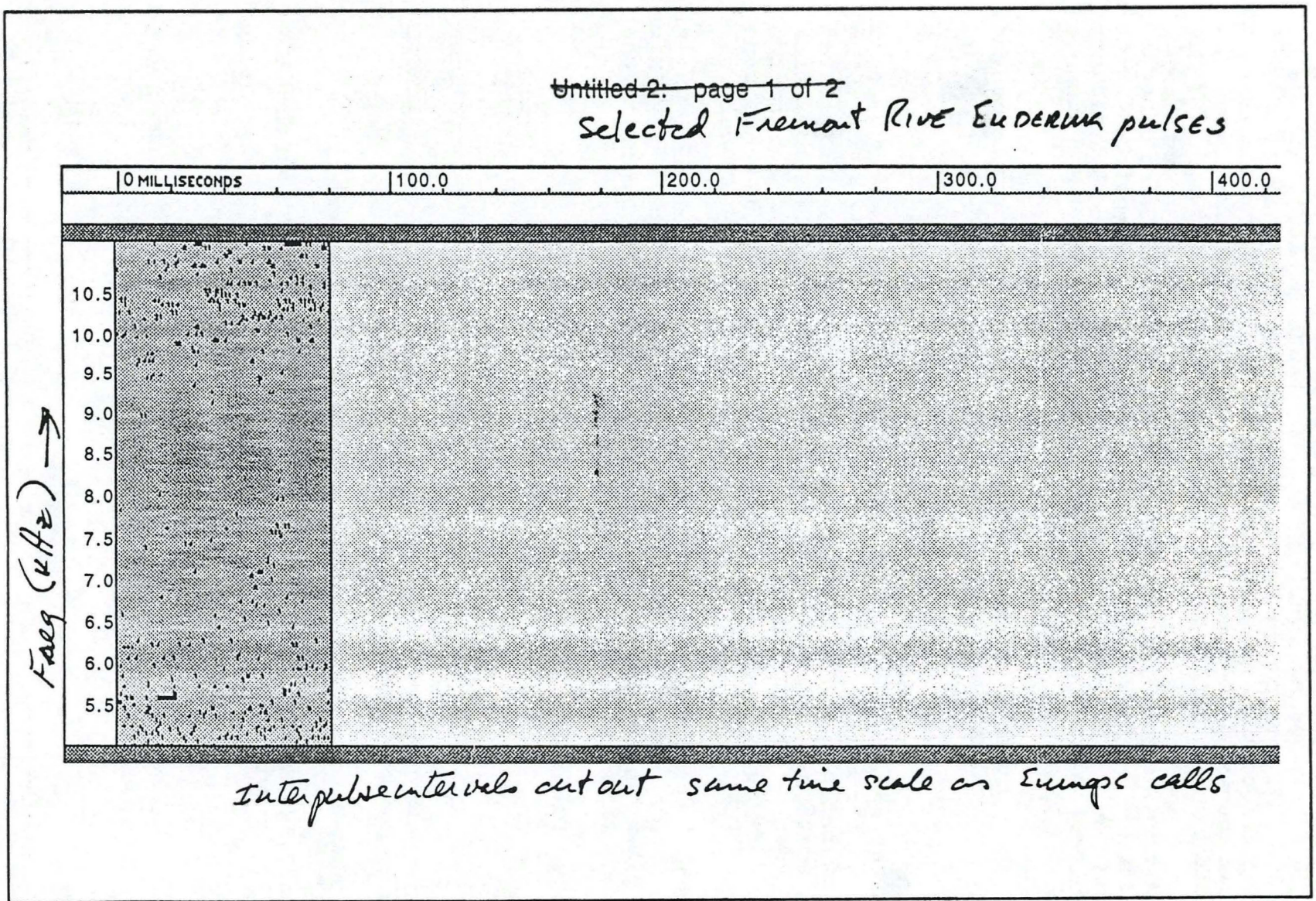

Figure 5. Selected *Euderma* pulses recorded during this survey, displayed on a sonogram produced by Bill Rainey.

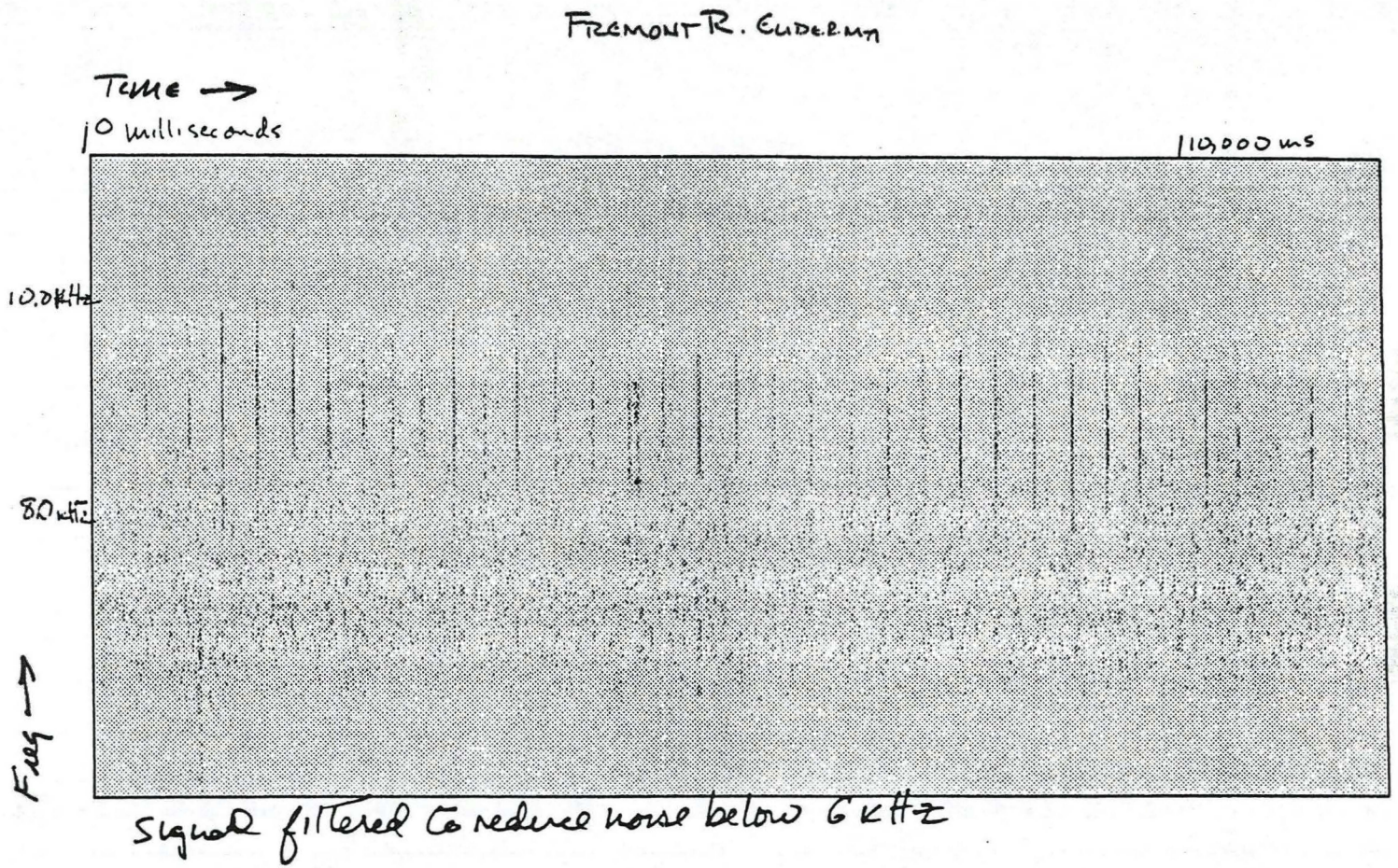

Figure 6. 10-second segment of *Euderma* pulses recorded during this survey, showing the frequency and intensity variations (produced by Bill Rainey).

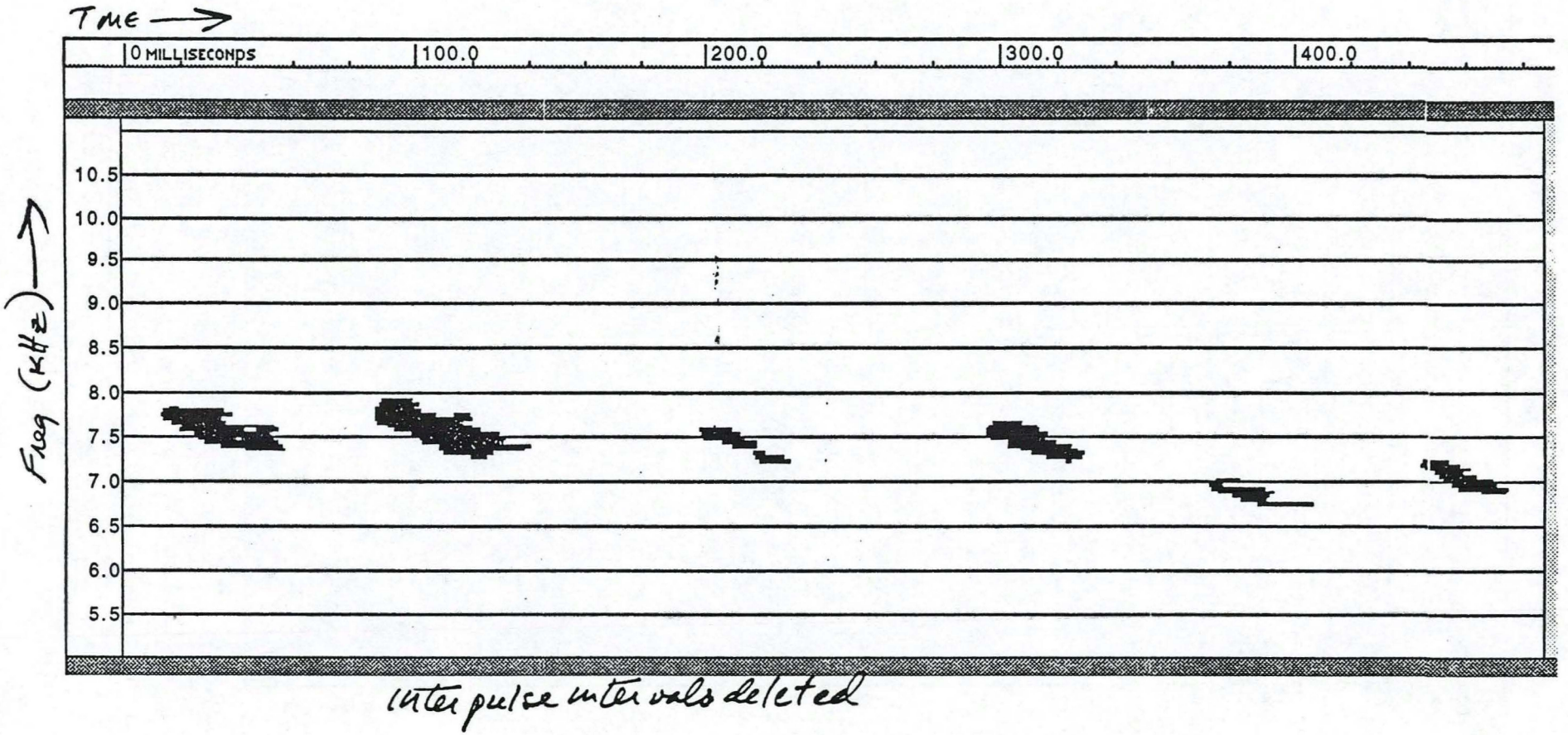

Figure 7. Selected *Eumops perotis* pulses recorded during this survey, shown at the same time scale as the *Euderma* pulses (Fig. 5) (produced by Bill Rainey).

DISCUSSION

Data and Observations

With respect to survey data, there does not seem to be any correlation between sites with increased audible bat activity and habitat type. Three sites, including both forests seemed to have increased audible bat activity: JVR sites 8 and 9 at the dam (MLNF), and site 3 near Little Duncan Mountain (FNF). The nightly bat activity at these sites was only consistent at JVR site 9. Likewise, in my 1991 Abajo Mountain survey, sites with higher levels of activity fluctuated nightly, and on one occasion seemed to be the result of increased smoke and insect levels from a prescribe burn near the study area.

The MLNF and FNF sites with high levels of activity have quite different habitat qualities. The JVR site is directly adjacent to large cliffs, a reservoir and high-flowing creek through a narrow canyon with mixed-conifers on the northern aspect (southside). The FNF site is a few miles distant from water and cliffs, and has rolling topography with small patches of mixed-conifers.

Additionally, even higher concentrations of audible bats were heard in developed rural areas, including well lit businesses like gas stations and motels from Price south to Wellington (Carbon County), the towns of Green River and Moab (Grand County), the town of Monticello and Abajo Mountains (San Juan County), and the town of Hanksville (Wayne County). All of these rural sites are nearly adjacent to large rivers, except Monticello and the Abajo Mountains. Likewise, most of these sites are nearly adjacent to cliffs except for Hanksville and Green River. The one commonality between the rural areas is the presence of bright business lights. This feature in addition to the apparent increased audible bat activity due to movement of insects during a fire as observed in the Abajo Mountains indicates that, as with other wildlife species, audible bats are congregating in areas with high prey abundance, and may travel great distances away from potential roosting areas to forage.

Echolocation Technique

Although echolocation surveys have recently become more popular, many limitations exist and this technique must be viewed as a method in development. Limitations include lack of knowledge, and priority, time and expense considerations. Lack of knowledge can be categorized further into equipment and regional information about species. There is a real misconception that simple bat detectors like the QMC Mini II can be used for bat species identification. Fenton (1988) suggests that the Mini II is insensitive to more than one frequency at a time, and this is a major limitation. The Mini II detector and other similar types do not provide enough acoustic information for accurate identification (Navo pers. comm., Rainey pers. comm).

To identify accurately bat species using detectors, a regional identification key of acoustic characteristics must be developed first, and used in concert with a more complex detector and associated equipment (recorder, software, and/or oscilloscope). The lowest frequency reading on the dial of the Mini II is 20 kHz, although this piece of equipment is supposed to pick up frequencies down to 15 kHz. This means for species echolocating below 20 kHz, the actual frequency reading is subjective. All three bats (*Euderma, I. phyllotis, N. macrotis*), considered audible, emit frequencies below 20 kHz. Therefore, it would be difficult to determine which species you are actually locating on the detector. Simple detectors like the Mini II are mainly useful for locating areas of bat activity and potential netting sites.

Lack of regional knowledge is another important limitation on the success of echolocation surveys. For example, Fenton (pers. comm.) and Navo (pers. comm.) claim that spotted bat calls are unique from the other audible/semi-audible bats. However, in the two field seasons that I have conducted spotted bat surveys, I have encountered many more audible bats in the eastern part of the state than expected. Fenton (pers. comm.) advised that since all the other audible/semi-audible species known from Utah are considered rare, and barely range into the state, we have locally common populations of spotted bats. However, I am not comfortable with the conclusions given the differences between the spotted bat call cassette recording I had and the calls heard in the field.

After reviewing more literature and museum records and consulting with additional researchers (Bogan pers. comm, O'Farrell pers. comm.), it appears that all three audible bats (*Euderma, I. phyllotis, N. macrotis*) are more widely distributed and abundant in Utah, especially the eastern region of the state, than previously believed. Currently, there are not any researchers who are adequately familiar with, or have experience working with, the acoustic aspects of more than two species of audible bat in a particular location. Also none of these researchers have experience with any combination of the audible bat species found in Utah. In Utah, discounting *P. townsendii* and the controversial *T. brasiliensis*, the three audible species (*Euderma, I. phyllotis,* and *N. macrotis*) are known from the same area of the state and use similar habitat types. Consequently, accurate acoustic information on these species is imperative for future surveys.

Beyond the advice of Fenton and Navo, I questioned other researchers about audible bats. There were almost as many answers as there were people questioned. For example, Mike Bogan (pers. comm.) claims that he has not heard *N. macrotis, I. phyllotis* or *Euderma* while capturing them. He did hear an audible bat that he said was not *Euderma*, its calls were more rapid but not as intense. According to published descriptions, this may have been *I. phyllotis* (Simmons and O'Farrell 1977). Lengas (pers. comm.) suggests after consulting with Dave Armstrong, a mammalogist in Colorado, that these audible bats might be *Antrozous pallidus*. However, none of these researchers have personal experience with

Antrozous (Navo pers. comm.), and both published information and knowledgeable individuals (Navo pers. comm., O'Farrell pers. comm.) claim that pallid bats use audible types of echolocation only for communication at the roosts, not orientation. After interviewing many people about bats they have heard and listening to bat calls in the field with other researchers present, it is evident that not everyone can hear the sounds of audible bats. The detail of calls heard varies as well and is an important consideration when conducting audible bat surveys and discussing results with other people.

Additionally, field personnel with limited knowledge about bats often automatically identify every audible bat as *Euderma*. For example, Rich Reynolds (pers. comm.), USFS Rocky Mountain Experiment Station, and his crew heard audible bats while working on the Kaibab Plateau in northern Arizona. Upon questioning, one of Reynolds' crew members told everyone that these were spotted bats. The description of the bat sounds Reynolds described sounded like what I have heard along eastern Utah. However, these could have been either the *Eumops perotis* that I recorded not far from their study area, *I. phyllotis* or *N. macrotis*. According to Bill Rainey (pers. comm.), this would represent slight northward range extension for *Eumops perotis* in Arizona. This area is not far from the Utah/Arizona border, suggesting that *Eumops* may occur in Utah and further complicating the possible results for audible bat echolocation surveys.

At some sites where a solitary audible bat is heard, a trained researcher could most likely distinguish between *Euderma* and the other possible audible species. Such was the case with the spotted bat I heard near Hanksville. However, at sites with many audible bats foraging together (i.e., JVR and areas of the Abajo Mountains), the determination is more difficult if not impossible without a sophisticated bat detector and associated equipment. It might be that in sites where many individuals of the other audible bat species are foraging together, there are enough bats that the echolocation pulse rates resemble those of *Euderma*, giving the impression that spotted bats are present when in reality they are not. Or, the impression might be that some *Euderma* are foraging with the other audible bats. This may have been the case when Fenton et al. (no date) heard at least 20 spotted bats foraging together at a site near St. George, Utah, and Poche (1981) described the sounds of *Euderma* echolocating in open-air flight. As with the 1991 and 1992 MLNF study areas, the other audible bats are present in the St. George area. However, there is still a chance that even a solitary bat emitting high-repetition-rate audible pulses might be one of the other species. *I. phyllotis* sounds somewhat like *Euderma* and the two could be confused by someone who has not heard both species.

However, after having personally heard *Euderma* and *I. phyllotis*, I feel it is safe to say that *Euderma* was heard near the JVR dam, and at the old Fish Creek Mine site near Stevens Creek, both on the Ferron Ranger District, MLNF, and at Snow Lake, FNF.

Priority, time and expense are important considerations when designing any wildlife survey. Since there are no federally listed "Endangered" or "Threatened" bats in Utah, bats in general have not been a priority for most wildlife and land managers. The Bureau of Land Management (Ron Bolander pers. comm.) and the UDWR (Pederson pers. comm.) are not currently engaged in bat surveys. It appears that the USFS has accomplished the greatest number of bat surveys in new areas statewide. Additionally, the amount of time involved to develop an identification key, and the expense involved in purchasing the proper equipment is considerable.

RECOMMENDATIONS FOR FUTURE SURVEYS

With the current low level of new bat survey efforts in Utah, it seems difficult to justify the cost of purchasing sophisticated equipment. However, in the long run, the use of echolocation survey techniques will become more efficient than strictly mist-netting. Considering both the lack of information available regarding bat species in Utah and habitat loss from the closing of abandoned mines, timber harvests, and potential subsidence from longwall mining, as well as potential negative impacts on prey species from pesticide spraying, bats may quickly become a group of animals in need of immediate management. The proactive approach (which may not be proactive at all considering the lack of current distribution, abundance and trend information available) would begin acquiring the appropriate equipment and developing an echolocation identification key for rare bat species using the search phase of the foraging sequence. Once we have accurately identified the audible bats, of importance is determining why these audible bats are congregating in areas and where are they roosting.

Since we now know that there are many more audible bats than expected in the eastern region of the state, all of which are probably rare and occur on lands administered by a variety of different agencies, it seems that a cooperative effort could be a possibility in purchasing equipment and in funding the surveys needed to develop the identification key. Once the key is developed, distribution and measures of relative activity could be used for long-term monitoring.

Although I am confident of the bat sounds I identified as *Euderma*, some biologists seem critical of the echolocation technique and would not accept these as a valid identifications. Consequently, a sonogram could be viewed as concrete evidence if the USFS feels that a confirmation of the presence of spotted bats is needed for management reasons. With the existing published sonogram of *Euderma* vocalizations, and the one obtained from Hanksville during this study, areas where *Euderma* have been heard on the MLNF (Abajo Mountains, Straight Canyon, and Stevens Creek) and FNF (Snow Lake) could easily be confirmed by spending a little time concentrating on recording the audible bat calls in these areas with the use of a detector like the QMC S-25.

Although I am still waiting for some crucial information on equipment and other technical aspects, I have included two preliminary survey alternatives and budgets for the initial echolocation work. All prices are approximate.

1. Minimum total equipment needed in-state for developing an echolocation identification key. Rare bat species would be the first species of focus. This technique would provide activity trends (foraging, roost site, etc.); other methods are needed for information relative to reproduction. Since the learning curve is steep for achieving proficiency with analysis of cassette recordings, production of sonograms, and use of the equipment, standardization would be met if one person or program maintained the responsibility for these items within the state. Ideally, various agency personnel could visit standard survey sites with a bat detector and recorder and send the recordings back to the one person in-state who would analyze the recording, produce sonograms, and provide a list of species present.

Equipment	**Price ($)**
1 QMC S-25 Bat Detector	900.00
1 set of sound analysis computer hardware and software to produce sonograms (computer not included)	6000.00
1 good quality recorder (minimum price)	300.00
1 set rechargeable batteries and recharger (estimated)	100.00
reflective powder	?
spotlight	25.00
TOTAL	7325.00

Since only one mist-net could be monitored at a time, the amount of equipment needed is geared to this level. Initially, one mist-net could be borrowed from sources in-state.

Personnel

At least two trained personnel are needed to work together to best monitor the equipment and net, and at least one should attend Dr. Brock Fenton's annual training session in Canada to learn the appropriate skills to operate the equipment and which combinations of equipment should be used. Fenton's training session will occur after the first full moon in August 1993, and costs $1,000.00 per person for materials, food and lodging while in Canada, and does not include transportation costs to Ontario. **Costs:** personnel, vehicle, per diem, and one training session.

2. Another way to initiate the identification key process at a somewhat reduced cost would be to forego the major expense of purchasing the sound analysis hardware/software and send the cassettes away for analysis. I asked Dixie Pierson and Bill Rainey, whether they would be willing to do this under a

contractual agreement, at what cost, and what type of bat detector and recording equipment they recommend. A reply is expected sometime in February 1993. This would work well while developing the key. After the key is developed, trained observers could use an oscilloscope in the field to make identifications.

I am interested in pursuing the initial stages of this process as a graduate research project. Otherwise it will be a long-term work accomplishment goal.

After the key is developed and surveys have provided Forest managers with a satisfactory knowledge of the distribution of rare bats, the next logical step would be to determine to what extent *Euderma* populations are using the Forest (i.e. roost sites, foraging habitat, prey type) so the habitat can be appropriately managed. This would require more in-depth surveys utilizing radio telemetry and prey analysis.

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APPENDIX 1 - 1992 *E. maculatum* Field Data, Manti-La Sal NF

Site: Straight Canyon
U.S.F.S. Ferron Ranger District

Observer: Robin Toone

Year: 1992

Spotted Bat Survey Form

Site #	Date	Time	# Bat Pass	# For. Buzz	Habitat Type	% Canopy Cover	Distance Water (m)	Distance Cliffs (m)
1a	8-11	11:13 P :28	Ø					
b	8-25	11:08p :23	1					
2a	8-11	11: 33 P :48	Ø					
b	8-25	10:51p 11:06	Ø					
3a	8-13	0:35a :50	3	very high-	pitched chirp, faint		(HP)	
b	8-25	10:34p :49	1	loud LS				
4a	8-13	0:53a 1:08	1					
b	8-25	10:17p :22	Ø					
5a	8-13	1:10a :25	Ø					
b	8-25	10:00p :15	Ø					
6a	8-13	1:26a :41	Ø					
b	8-25	9:43p :58	Ø					
7a	8-13	1:42a :57	Ø					
b	8-25	9:27p :42	Ø					
8a	8-13	1:58a 2:13	1	LS				
b	8-25	9:10p :25	11	1	both constant and Increased Frequencies		LS, LF	
9a	8-13	2:17a :32	9		LS, LF			
b	8-25	8:50 p 9:05	16	(probably at least	2 Spotted bats)		low-frequency clicks high reps.	

Comments: Creek very noisy. 8/11 Cindy Burns and I listened for 15 min. at Laurie water turnoff, Ø passes.

Site: Cottonwood Canyon
U.S.F.S. Ferron Ranger District

Observer: Robin Toone

Year: 1992

Spotted Bat Survey Form

Site #	Date	Time	# Bat Pass	# For. Buzz	Habitat Type	% Canopy Cover	Distance Water (m)	Distance Cliffs (m)
1a	8-13	2:50a 3:05	Ø					
b	8-25	11:26p :41	Ø					
2a	8-13	3:07a :22	Ø					
b	8-25	:43a :58	Ø					
3a	8-13	3:24a :39	Ø					
b	8-26	00:00a :15	Ø					
4a	8-13	3:41a :56	Ø					
b	8-26	0:17a :22	Ø					
5a	8-13	3:58a 4:13	? Ø					
b	8-26	12:36a :51	Ø					
6a	8-13	4:15a :30	Ø					
b	8-26	00:53a 1:08	Ø					
7a	8-13	4:32a :47	Ø					
b	8-26	1:10a :25	Ø					
8a	8-13	4:49a 5:04	Ø					
b	8-26	1:28a :43	Ø					
9a	8-13	5:21a :36	Ø					
b	8-26	1:45a 2:00	Ø					
1	8-13	9:30p 10:30	3	not 15 min.				

Convulsion mine

Comments - at site #5 a very high pitched and faint "cha che" was heard. I was very tired and am not certain about what I heard.

=: Newberry Canyon Observer: Robin Toone

ar: 1992

Spotted Bat Survey Form Page 3 of 3

Site: Huntington Canyon U.S.F.S. Price Ranger District

Site #	Date	Time	# Bat Pass	# For. Buzz	Habitat Type	% Canopy Cover	Distance Water (m)	Distance Cliffs (m)
1a	8-14	0:30a :45	Ø					
b	8-26	2:35a :50	Ø					
1a	8-6	9:50p 10:05	Ø	(0.4 mi passed Forest Boundary)				
b	8-27	8:45p 9:00	Ø					
2a	8-6	10:07p :22	Ø	(0.7 mi)				
b	8-27	9:02p :17	Ø					
3a	8-14	2:53 a 3:08	Ø	(0.6 mi)				
b	8-27	9:21p :36	Ø					
4a	8-14	3:10 a :25	Ø	(0.7 mi)				
b	8-27	9:39p :54	Ø					
5a	8-18	3:26 a :41	Ø	(1.0 mi)				
b	8-27	9:57p 10:12	Ø					
6a	8-18	3:43 a :58	Ø	(0.5 mi) 9 coal trucks in 15 min.				
b	8-27	10:15p :30	Ø					
7a	8-18	3:15 a :30	Ø	(1.2 mi)				
b	8-27	10:33p :48	2	high-pitched w/ increased rate				
8a	8-18	3:31a :46	Ø					
b	8-27	10:51p 11:06	Ø	(0.8 mi)				
9a	8-18	3:48a 4:03	Ø	Electric Lake				
b	8-27	11:10p :25	Ø	(0.6 mi)				

Comments: Huntington Canyon - creek noisy, too many coal trucks to safely pull off road, they're very noisy also.

APPENDIX 2 - 1992 *E. maculatum* Field Data, **Fishlake NF**

Site: Jack Adley Monument — Observer: Robin Toone

Fishlake N.F.

Year: 1992

Spotted Bat Survey Form

Site #	Date	Time	# Bat Pass	# For. Buzz	Habitat Type	% Canopy Cover	Distance Water (m)	Distance Cliffs (m)
1a	8-18	23:31 :46	6	high-pitched				
b	8-27	2:30 :45	2					
2a	8-18	23:51 0:06	4	high-pitched				
b	8-27	2:47 3:02	Ø					
3a	8-18	0:13 :28	4	high-pitched				
b	8-27	3:04 :19	Ø					

Site: Little Duncan to Corral Knob
Fishlake National Forest

Site #	Date	Time	# Bat Pass	# For. Buzz	Habitat Type	% Canopy Cover	Distance Water (m)	Distance Cliffs (m)
1a	8-18	20:40 :55	6	high-pitched				
b	8-27	0:25 :40	1					
2a	8-18	21:00 :15	Ø					
b	8-27	0:42 :57	1					
3a	8-18	21:20 :35	Ø					
b	8-27	0:59 1:14	9					
4a	8-18	21:43 :58	Ø					
b	8-27	1:16 :31	Ø					
5a	8-18	22:04 :19	2	high-pitched, very faint				
b	8-27	1:33 1:48	1					
6a	8-18	22:27 :42	1	high-pitched, louder than at # 5.				
b	8-27	1:50 2:05	3					
7a	8-18	22:54 23:09	1	high-pitched				
b	8-27	2:08 :23	1					

Site: Snow Lake
Year: 1992

Observer: Robin Toone

Spotted Bat Survey Form

Site #	Date	Time	# Bat Pass	# For. Buzz	Habitat Type	% Canopy Cover	Distance Water (m)	Distance Cliffs (m)
1a	8-17	22:07 :22	4	1 chirps, metallic change, 1 soft, 2 loud, constant. (Epidermia)				
b	8-26	20:35 :50	2	high-pitched, faint				
2a	8-17	22:25 :40	2	high pitched chirps, constant about 3/sec,				
b	8-26	20:53 21:08	2	high-pitched				
3a	8-17	22:42 :57		1				
b	8-26	21:10 :25	2					
4a	8-17	22:58 23:13	2	1 high-pitched (farther away) 1 change-in-rate close				
b	8-26	21:27 :42	1	high-pitched				
5a	8-17	23:17 :32	∅					
b	8-26	21:44 :59	3	high-pitchrd, faint				
6a	8-17	23:34 :49	2					
b	8-26	22:00 :15	∅					

APPENDIX 3 - Maps of 1992 *E. maculatum* Probable Locations and Survey Sites, Manti-La Sal NF

Map 1. 1992 Huntington Canyon Survey Route, Hiawatha Quadrangle; 1:24,000.

Map 2. 1992 Huntington Canyon Survey Route, Rilda Canyon Quadrangle; 1:24,000.

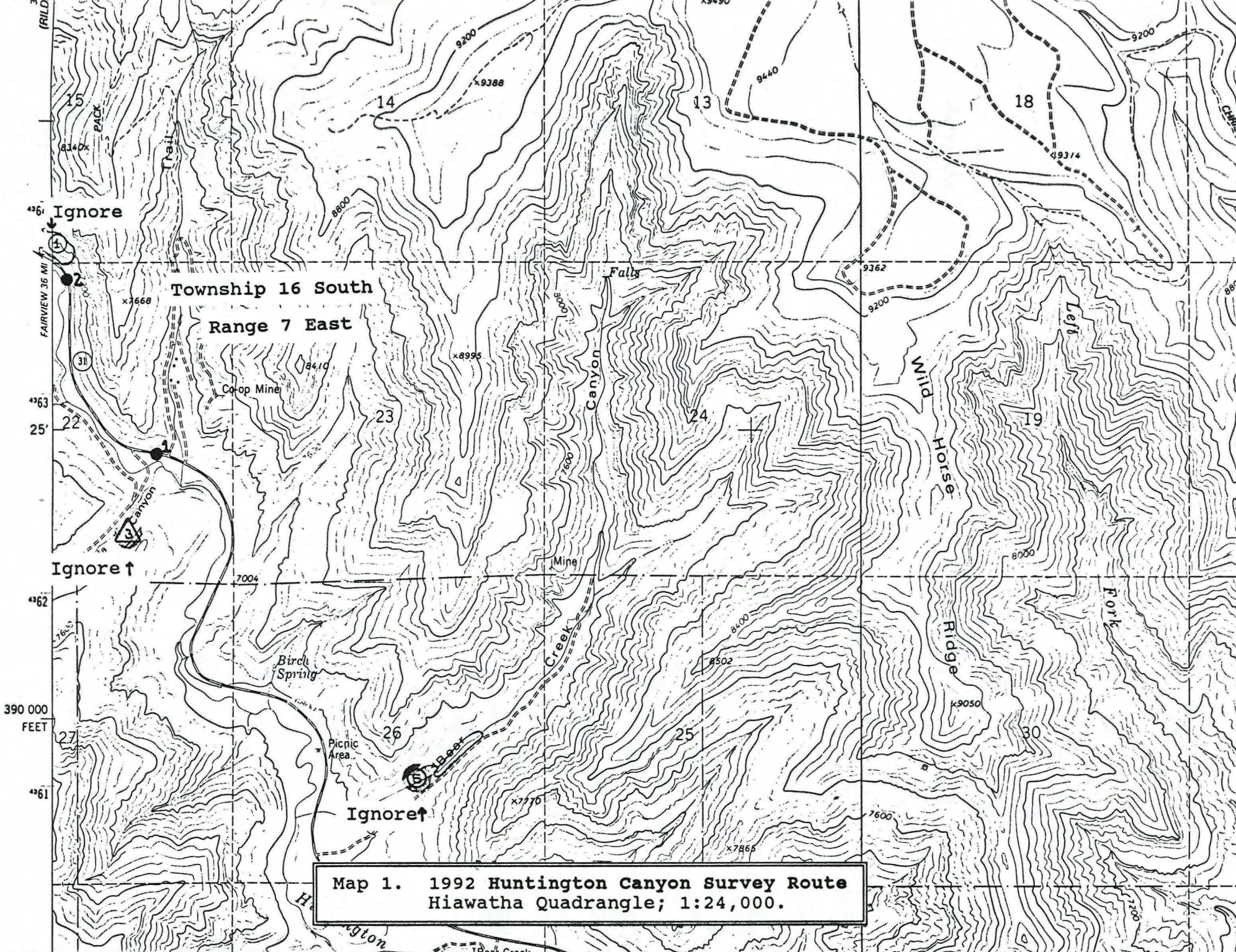
Map 3. 1992 Huntington Canyon Survey Route, Candland Mtn. Quadrangle; 1:24,000.

Map 4. 1992 Straight Canyon Survey Route, Mahogany Point Quadrangle; 1:24,000.

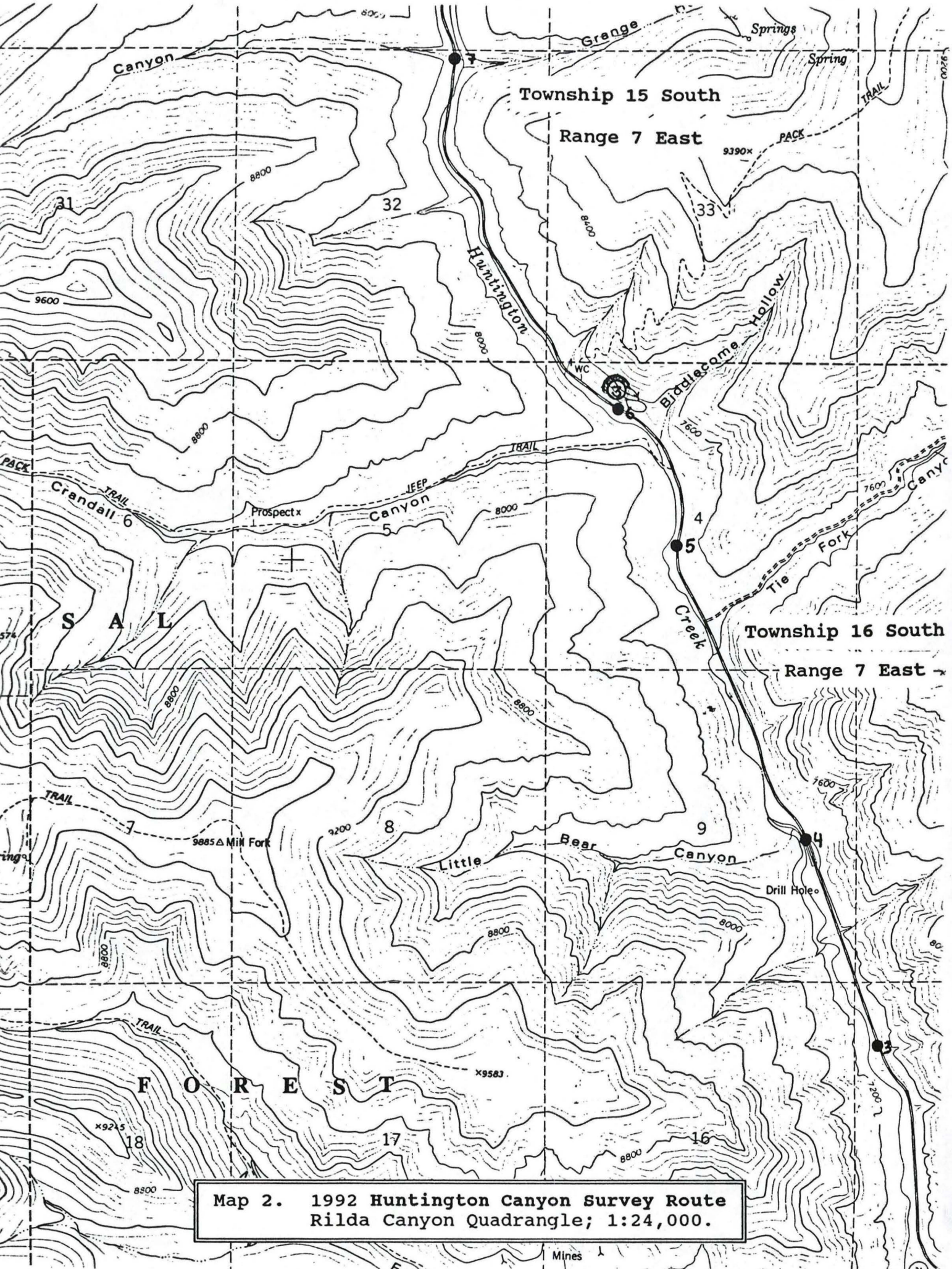
Map 5. 1992 Straight Canyon Survey Route, Joe's Valley Reservoir Quadrangle; 1:24,000.

Map 6. 1992 Cottonwood Canyon Survey Route, Mahogany Point Quadrangle; 1:24,000.

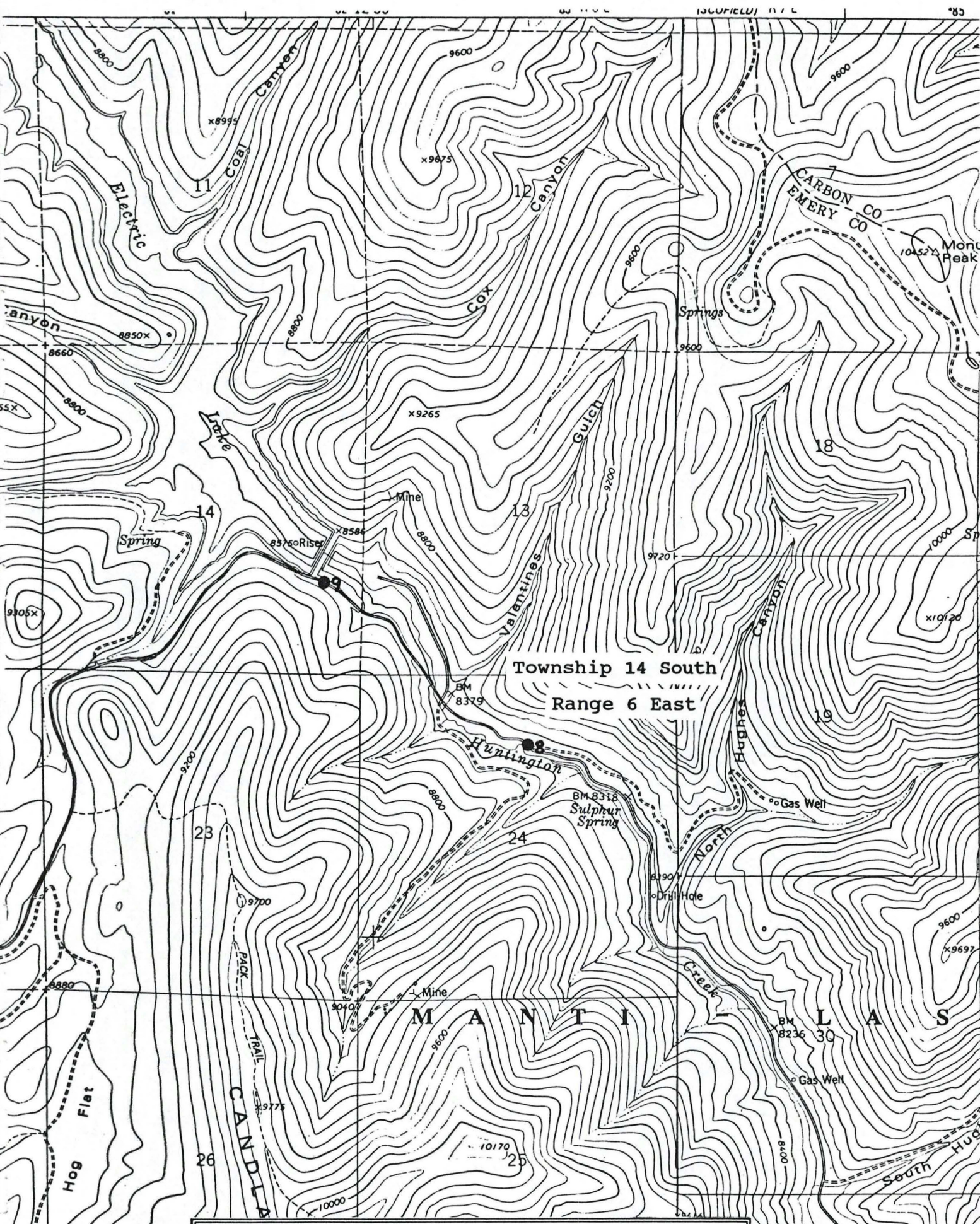
Map 7. 1992 Quichupah Creek Survey Route, Accord Lakes & Emery West Quadrangle; 1:24,000.



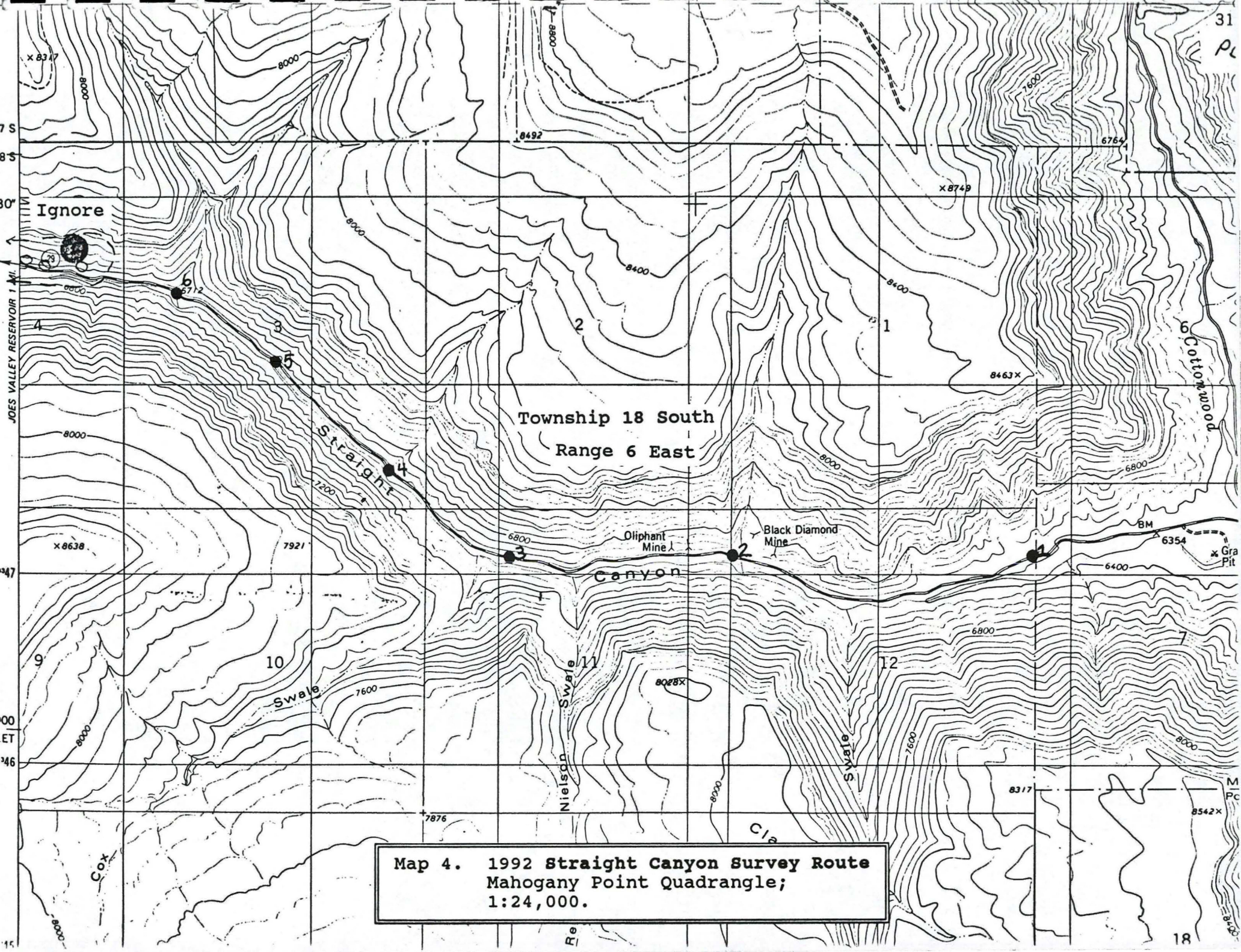
Map 1. 1992 Huntington Canyon Survey Route
Hiawatha Quadrangle; 1:24,000.



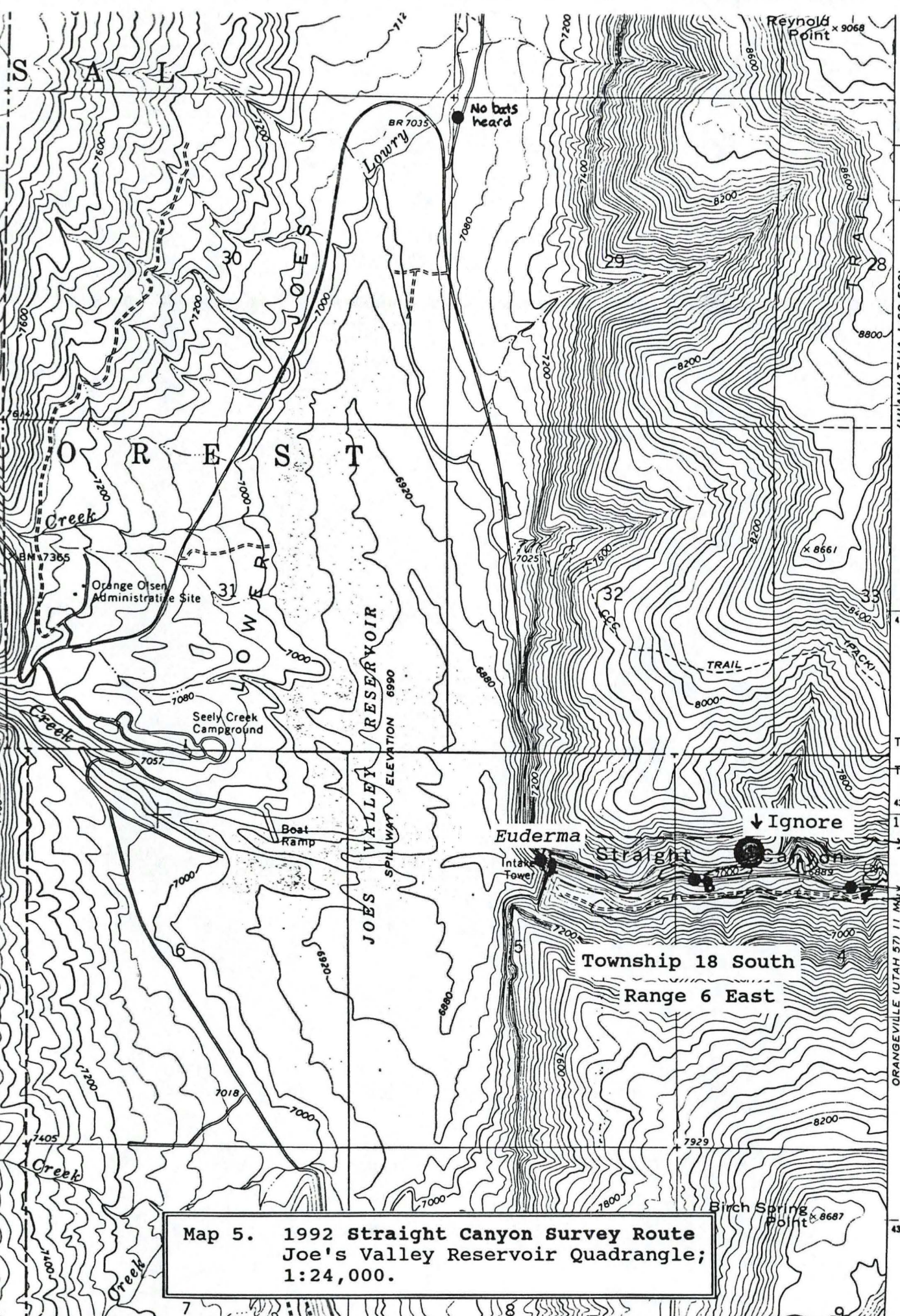
Map 2. 1992 Huntington Canyon Survey Route
Rilda Canyon Quadrangle; 1:24,000.



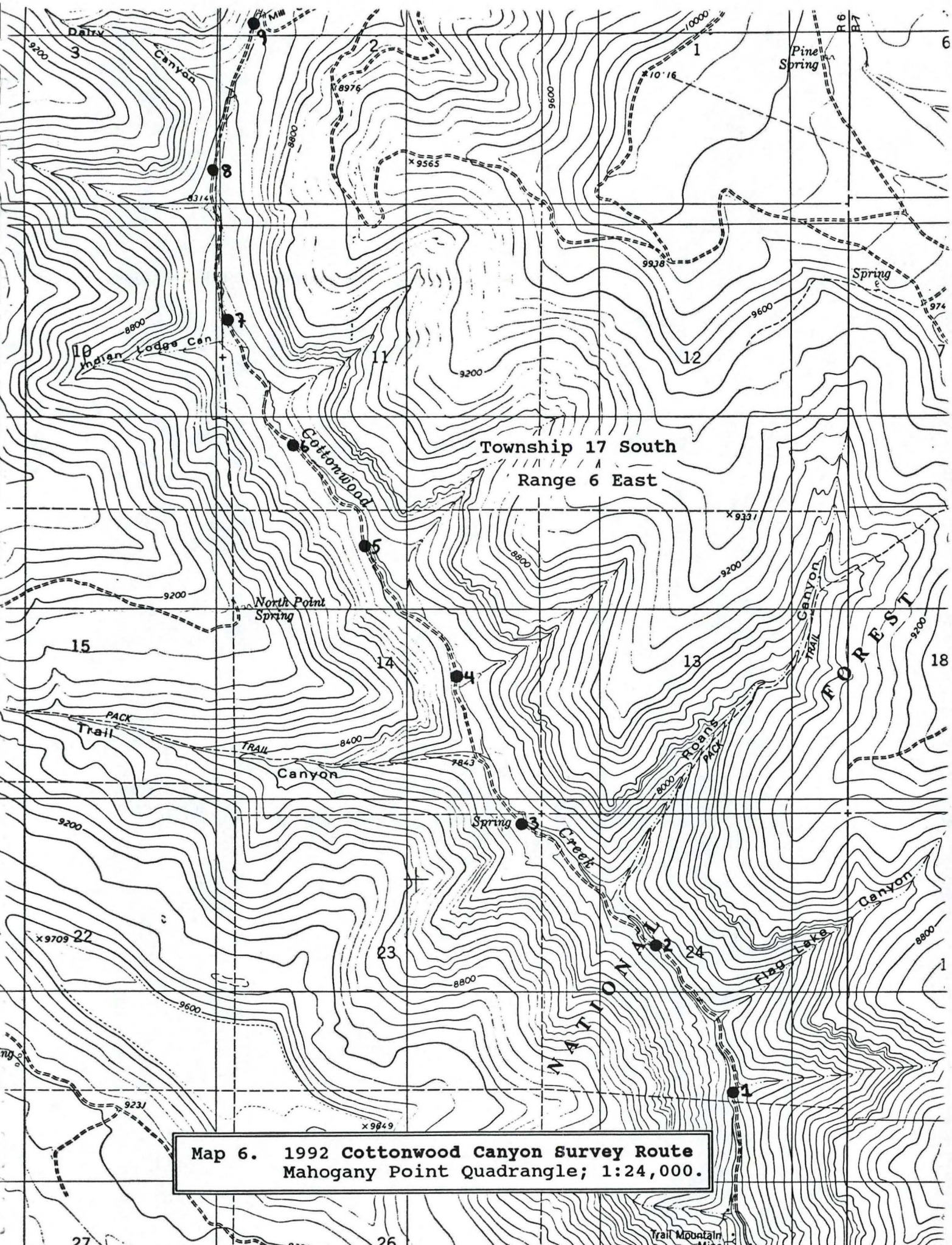
Map 3. 1992 **Huntington Canyon Survey Route**
Candland Mtn. Quadrangle; 1:24,000.



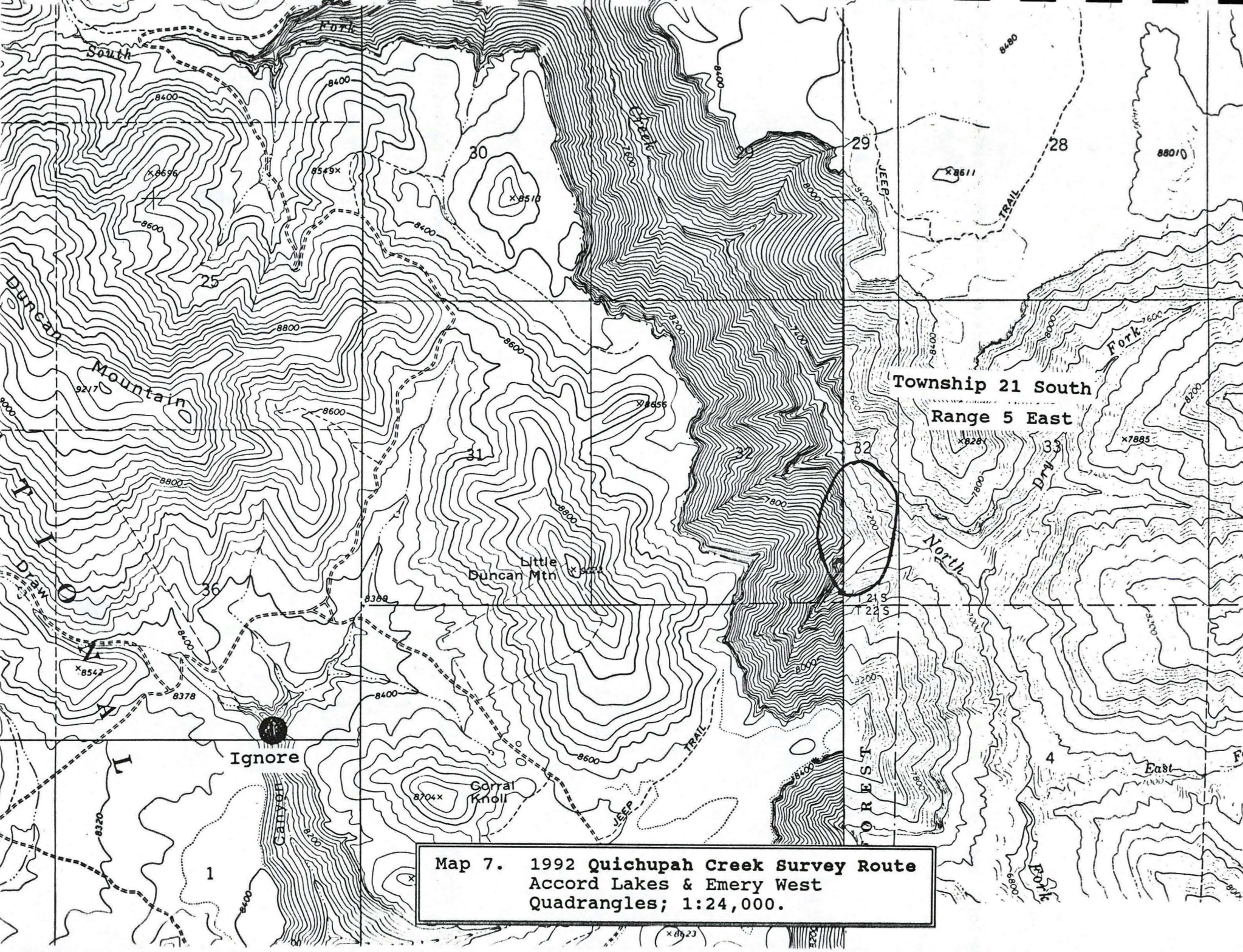
Map 4. 1992 **Straight Canyon Survey Route**
Mahogany Point Quadrangle;
1:24,000.



Map 5. 1992 **Straight Canyon Survey Route** Joe's Valley Reservoir Quadrangle; 1:24,000.



Map 6. 1992 Cottonwood Canyon Survey Route
Mahogany Point Quadrangle; 1:24,000.

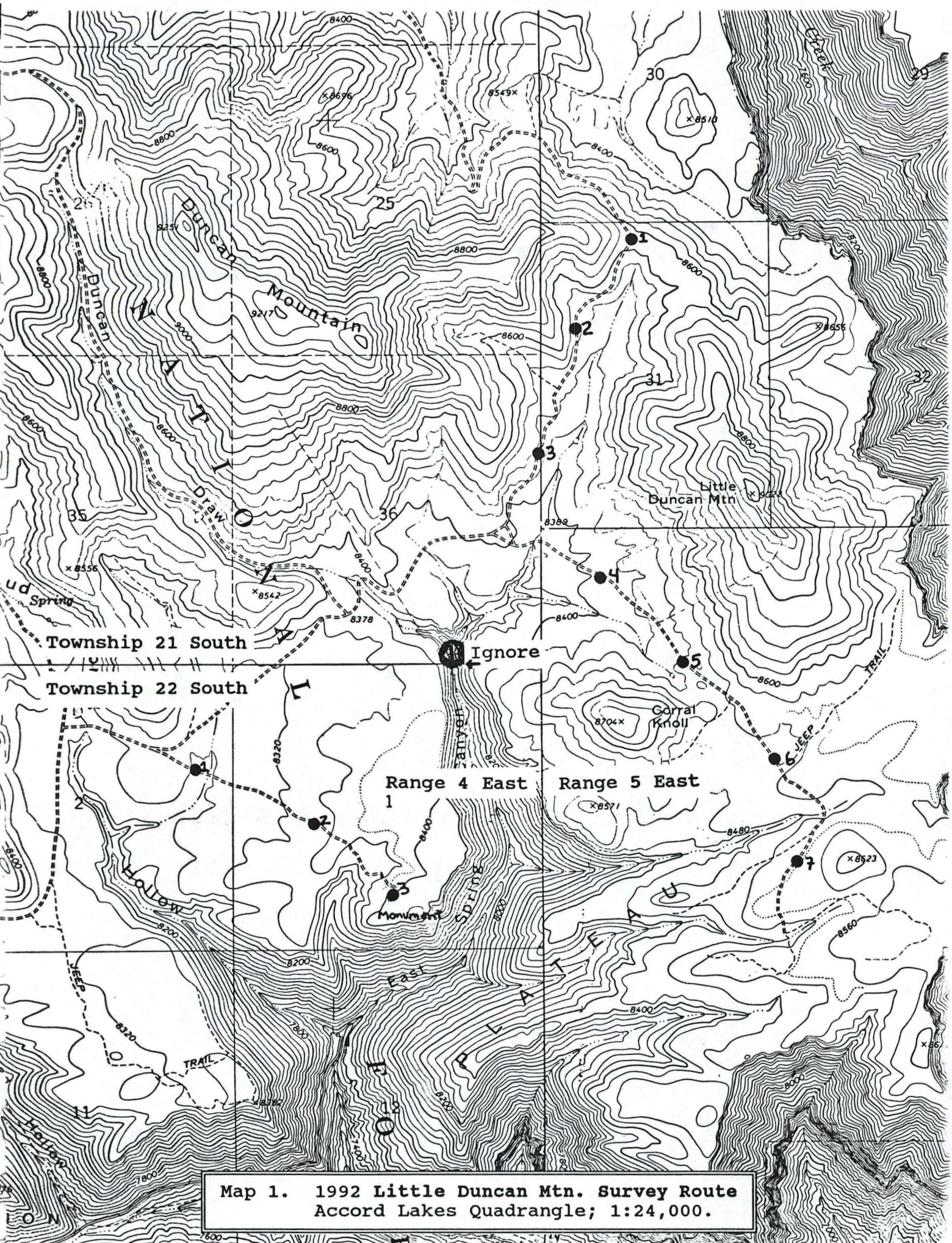


Map 7. 1992 **Quichupah Creek Survey Route**
Accord Lakes & Emery West
Quadrangles; 1:24,000.

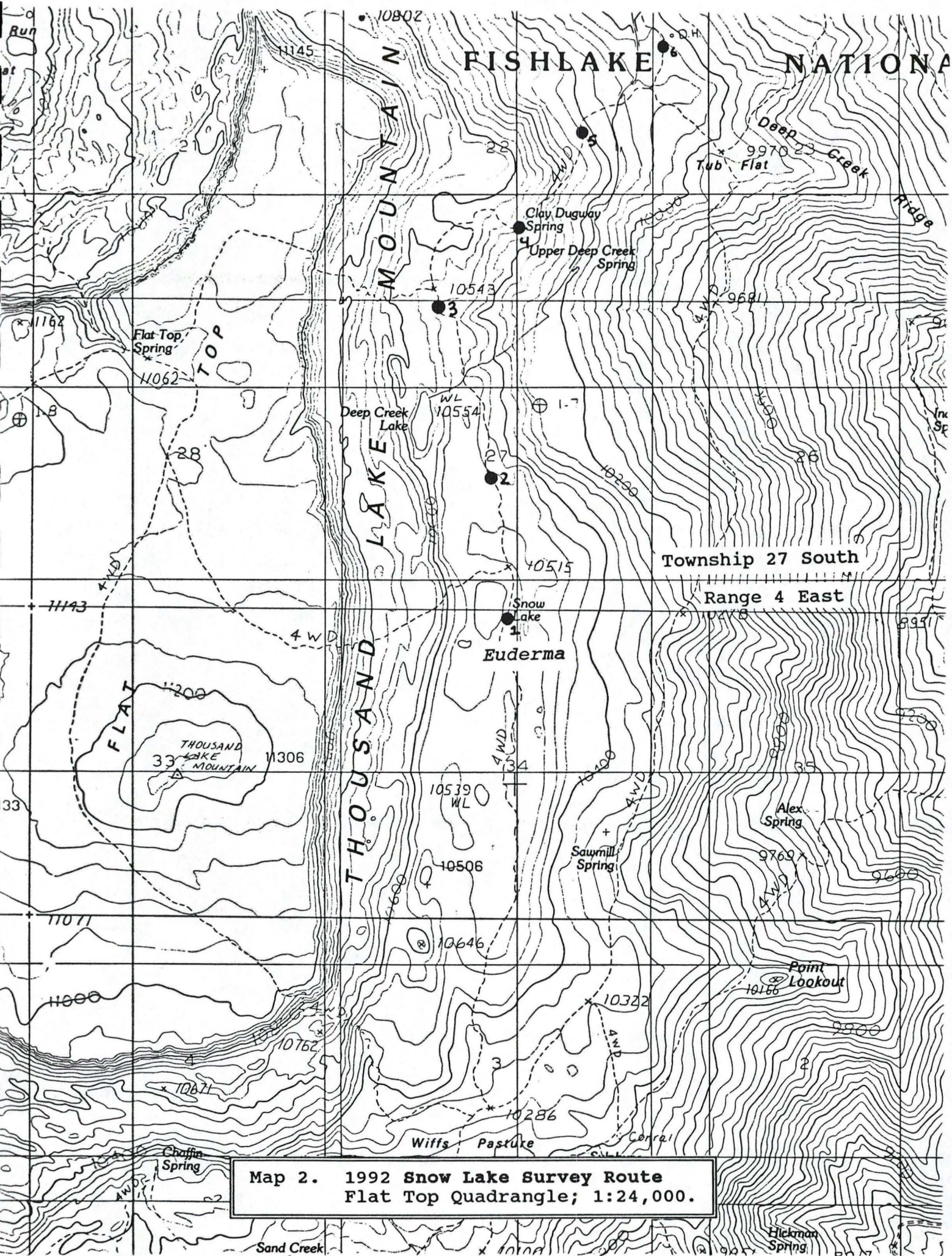
APPENDIX 4 - Maps of 1992 *E. maculatum* Probable Locations and Survey Sites, **Fishlake NF**

Map 1. 1992 Little Duncan Mtn. Survey Route, Accord Lakes Quadrangle; 1:24,000.

Map 2. 1992 Snow Lake Survey Route, Flat Top Quadrangle; 1:24,000.



Map 1. 1992 Little Duncan Mtn. Survey Route
Accord Lakes Quadrangle; 1:24,000.



Map 2. 1992 **Snow Lake Survey Route**
Flat Top Quadrangle; 1:24,000.

APPENDIX 5 - Photographs of Audible/Semi-Audible Bats, Known *Euderma* Habitat, and Study Areas (both Forests).

Audible/Semi-Audible Bat Species

Photo 1. *Euderma maculatum*, specimen from the Museum of Natural History, University of Utah.

Photo 2. *Euderma maculatum*, specimen from the Museum of Natural History, University of Utah.

Photo 3. *Idionycteris phyllotis*, captured and released from the mouth of Mill Creek Canyon, Moab, Grand County on 28 September 1992.

Photo 4. *Idionycteris phyllotis*, captured and released from the mouth of Mill Creek Canyon, Moab, Grand County on 28 September 1992.

Photo 5. *Plecotus townsendii*, Ferron Utah, photo courtesy of Dale Harber, Ferron Ranger District, Manti-La Sal National Forest.

Known *Euderma* Locations

Photo 6. *Euderma maculatum* known location, Fort Pierce Wash (T43S R14W), Washington County.

Photo 7. *Euderma maculatum* known location, Fort Pierce Wash (T43S R14W), Washington County.

Manti-La Sal National Forest Study Areas

Photo 8. View of study area, Straight Canyon (T18S R6E Section 5), Ferron Ranger District, Manti-La Sal National Forest.

Photo 9. *Euderma maculatum* heard at this site. Joe's Valley Reservoir Dam (T18S R6E Section 5), Straight Canyon, Ferron Ranger District, Manti-La Sal National Forest.

Photo 10. View of study area, Cottonwood Canyon (T17S R6E Section 11), Ferron Ranger District, Manti-La Sal National Forest.

Photo 11. View of study area, Newberry Canyon (T17S R7E Section 27), Ferron Ranger District, Manti-La Sal National Forest.

Photo 12. View of study area, Lower Huntington Canyon (T16S R7E Section 9), Price Ranger District, Manti-La Sal National Forest.

Fishlake National Forest Study Areas

Photo 13. View of study area, Little Duncan Mountain (T21S R5E Section 31), Richfield Ranger District, Fishlake National Forest.

Photo 14. View of study area, Corral Knoll (T22S R5E Section 6) Richfield Ranger District, Fishlake National Forest.

Photo 15. View of study area, Jack Adley Monument (T22S R4E Section 1), Richfield Ranger District, Fishlake National Forest.

Photo 16. *Euderma maculatum* heard at this site. Snow Lake area (T27S R4E Section 27, 34), Loa Ranger District, Fishlake National Forest.

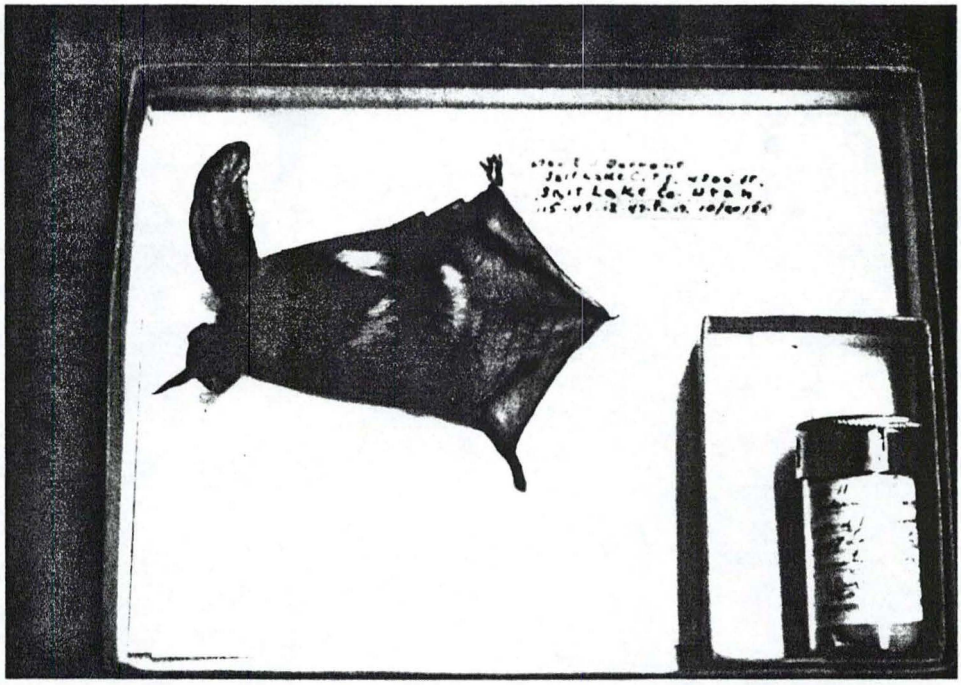


Photo 1. *Euderma maculatum*, specimen from the Museum of Natural History, University of Utah.

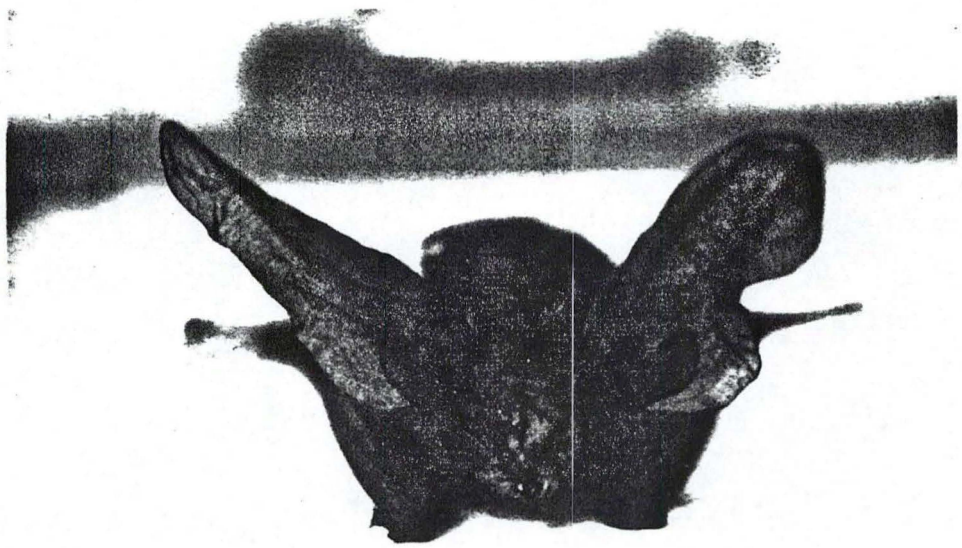


Photo 2. *Euderma maculatum*, specimen from the Museum of Natural History, University of Utah.

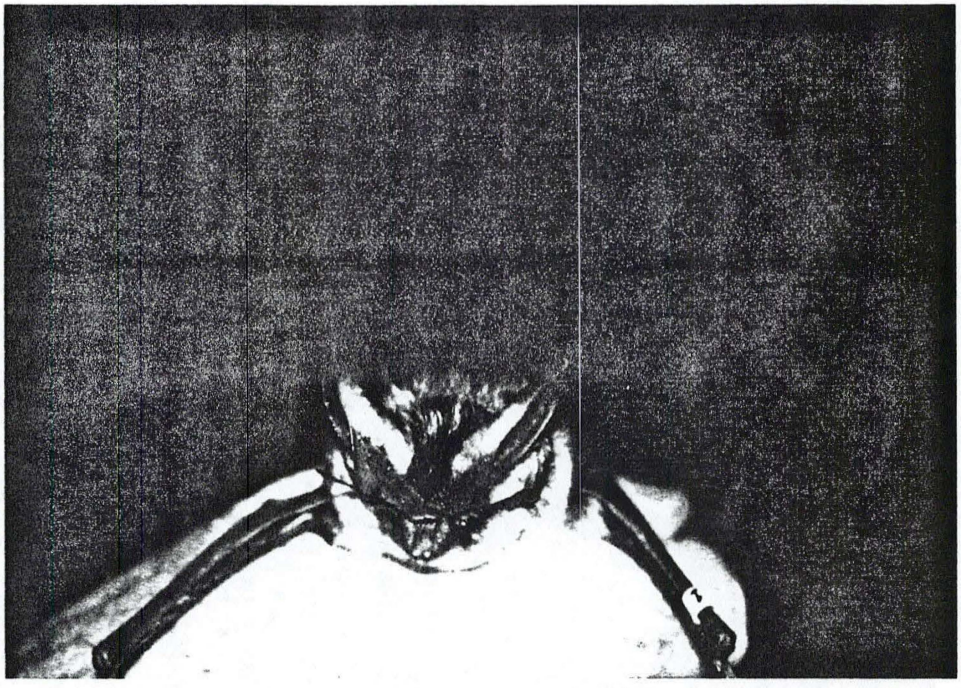


Photo 3. *Idionycteris phyllotis*, captured and released from the mouth of Mill Creek Canyon, Moab, Grand County on 28 September 1992.

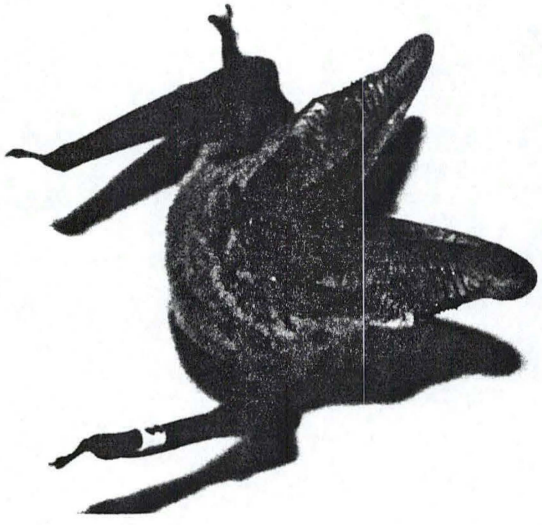


Photo 4. *Idionycteris phyllotis*, captured and released from the mouth of Mill Creek Canyon, Moab, Grand County on 28 September 1992.

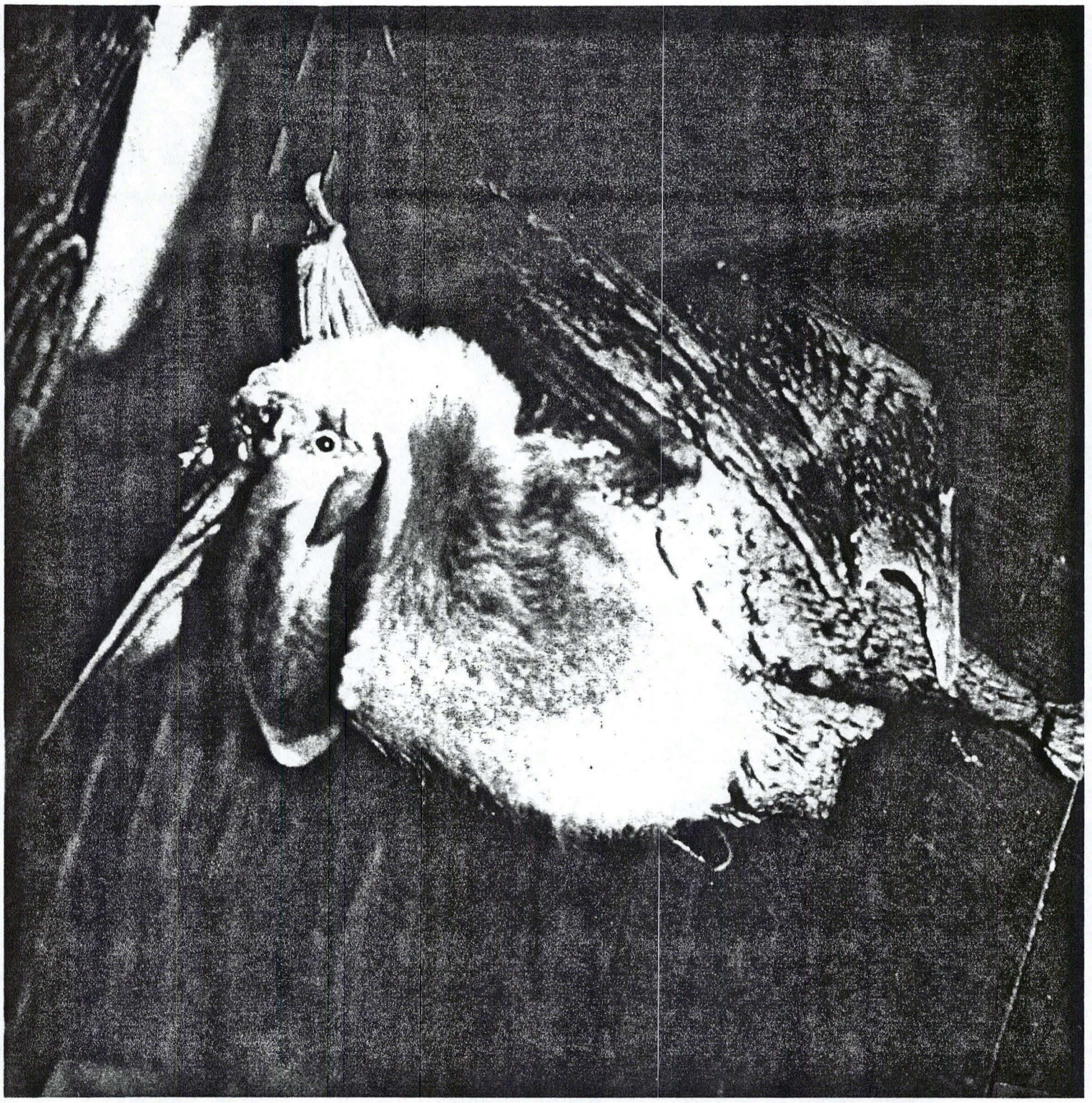


Photo 5. *Plecotus townsendii*, Ferron Utah, photo courtesy of Dale Harber, Ferron Ranger District, Manti-La Sal National Forest.

Known *Euderma* Locations

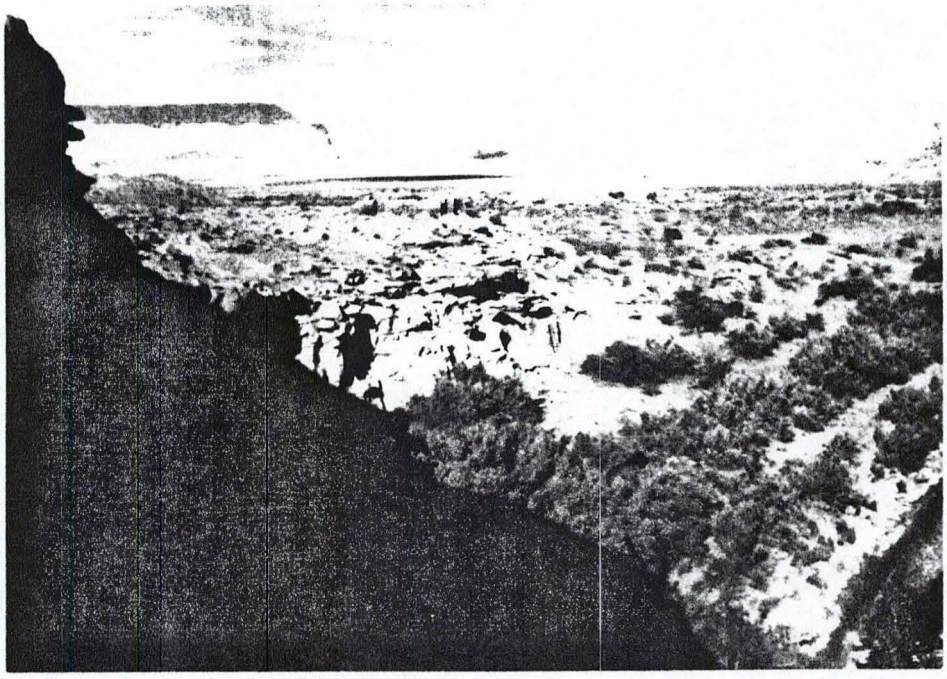


Photo 6. *Euderma maculatum* known location, Fort Pierce Wash (T43S R14W), Washington County.

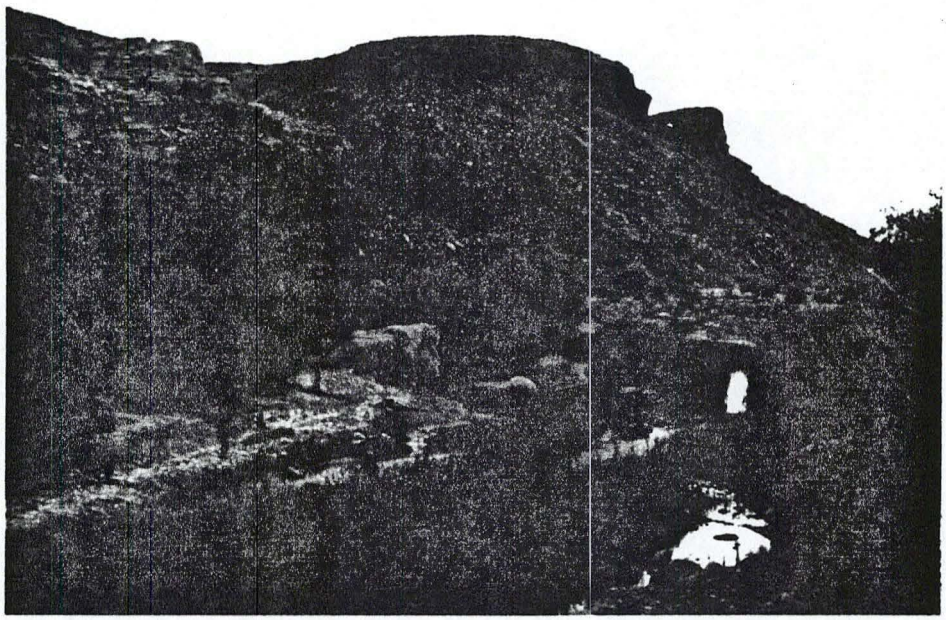


Photo 7. *Euderma maculatum* known location, Fort Pierce Wash (T43S R14W), Washington County.

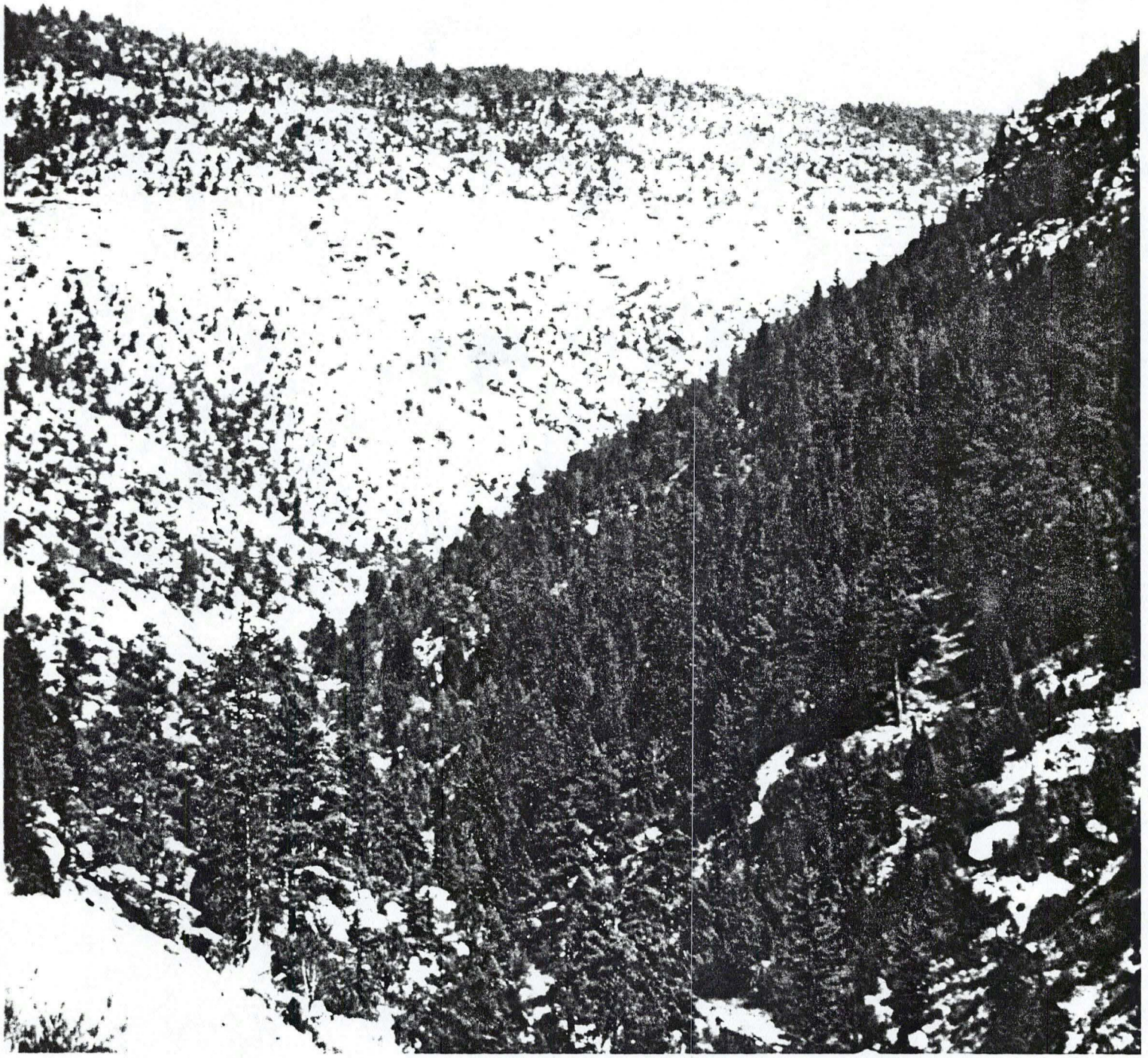


Photo 8. View of study area, Straight Canyon (T18S R6E Section 5), Ferron Ranger District, Manti-La Sal National Forest.

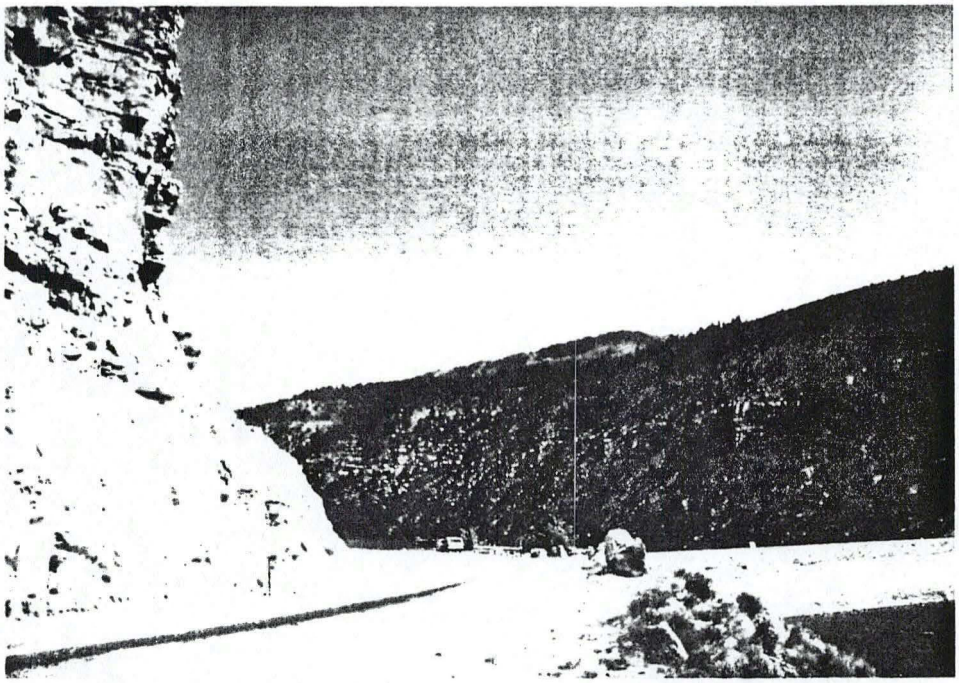


Photo 9. *Euderma maculatum* heard at this site. Joe's Valley Reservoir Dam (T18S R6E Section 5), Straight Canyon, Ferron Ranger District, Manti-La Sal National Forest.

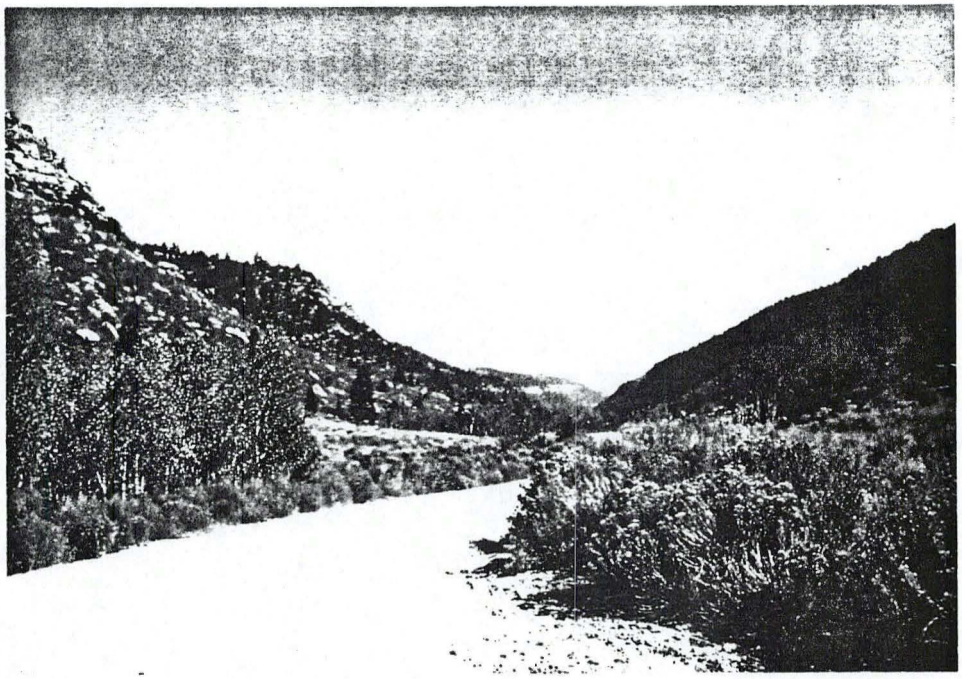


Photo 10. View of study area, Cottonwood Canyon (T17S R6E Section 11), Ferron Ranger District, Manti-La Sal National Forest.

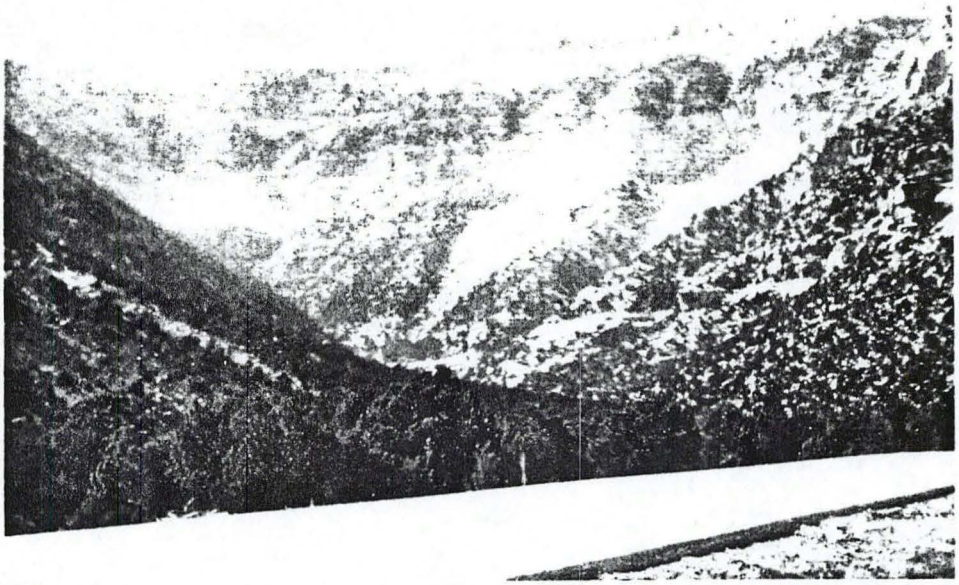


Photo 11. View of study area, Newberry Canyon (T17S R7E Section 27), Ferron Ranger District, Manti-La Sal National Forest.

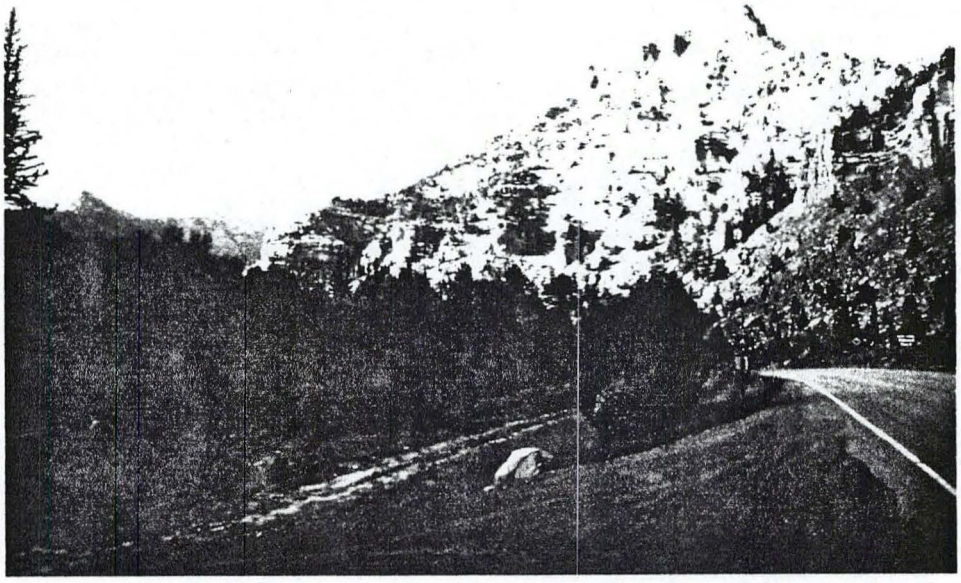


Photo 12. View of study area, Lower Huntington Canyon (T16S R7E Section 9), Price Ranger District, Manti-La Sal National Forest.

Fishlake National Forest Study Areas

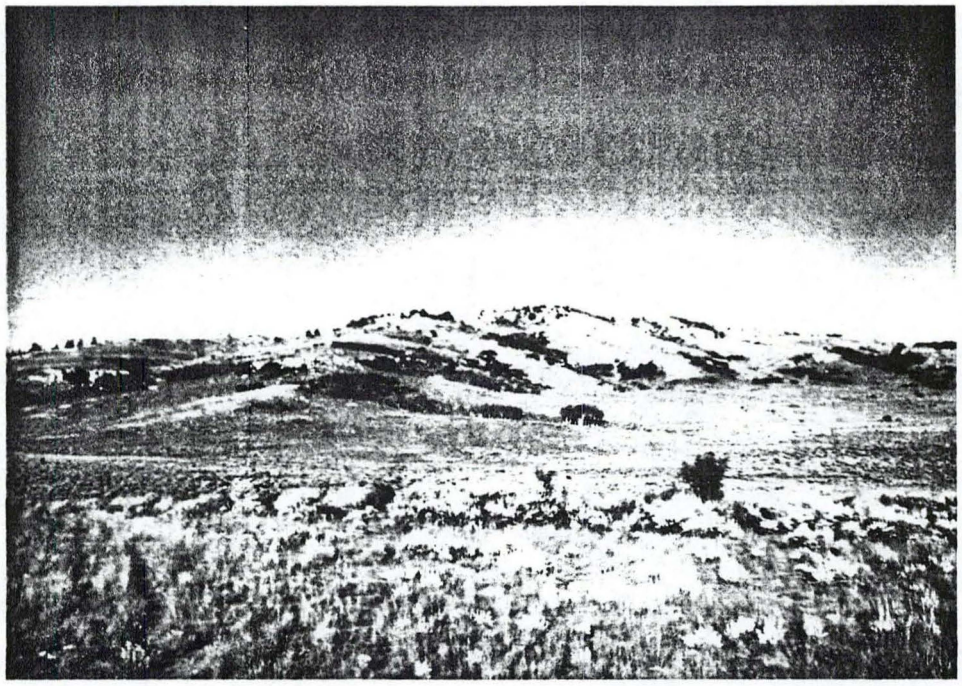


Photo 13. View of study area, Little Duncan Mountain (T21S R5E Section 31) , Richfield Ranger District, Fishlake National Forest.

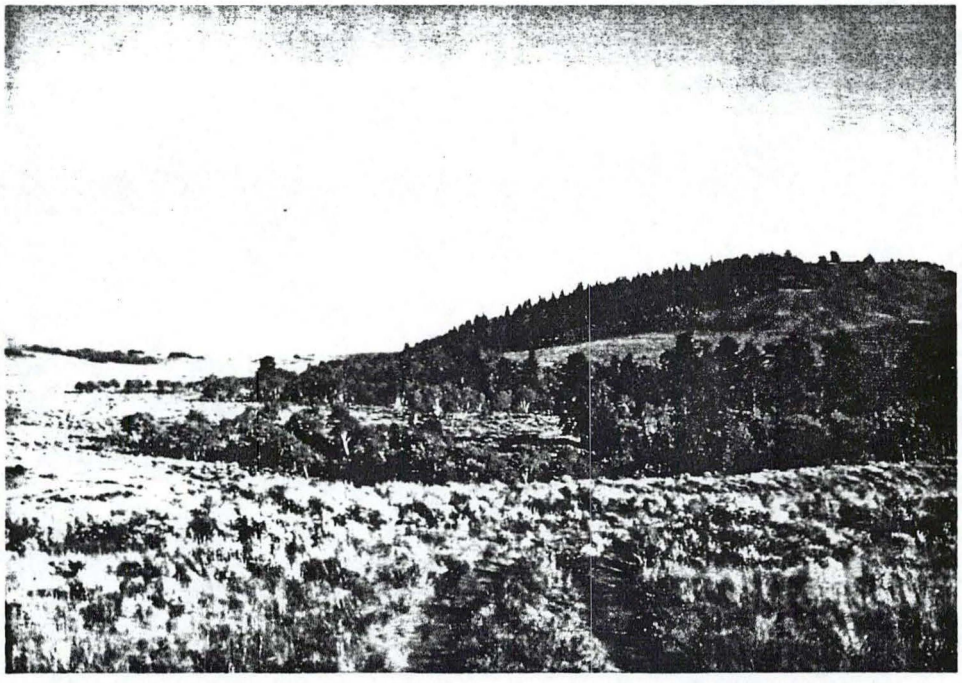


Photo 14. View of study area, Corral Knoll (T22S R5E Section 6) Richfield Ranger District, Fishlake National Forest.

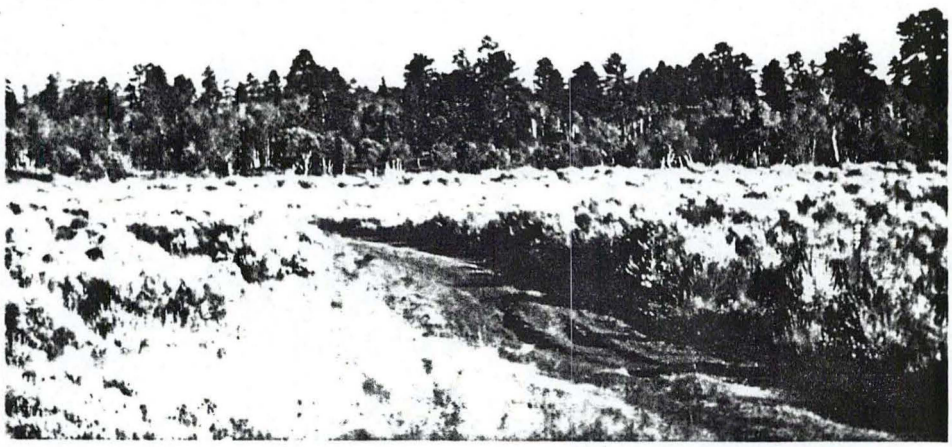


Photo 15. View of study area, Jack Adley Monument (T22S R4E Section 1), Richfield Ranger District, Fishlake National Forest.

Photo 16. View of study area, Snow Lake Area (T27S R4E Section 27, 34), Loa Ranger District, Fishlake National Forest.

APPENDIX 6 - Museum Records of *E. maculatum*

This appendix contains all the *Euderma maculatum* collection information for Utah from the University of Utah's (UU) Museum of Natural History and Brigham Young University's (BYU) M. L. Bean Museum. The information is summarized in the following order: institution; collection number; age and sex; collectors; collection locality; elevation; habitat; date. A category was skipped if the information was not available.

Grand County:

1. UU; Moab; May 8, 1959.

Salt Lake County:

1. UU; 1135; Salt Lake City; November 20, 1934.

Tooele County:

1. USFWS (Susan Linner pers. comm.).

Utah County:

1. BYU; 1681; ♂; Provo; July 15, 1959.

Washington County:

1. BYU; Fort Pierce Wash; June 18, 1991.

2. BYU; Fort Pierce Wash; June 21, 1991.